EVALUATION OF IMPEDIMENTS TO THE COMPETITIVENESS OF THE RAIL SECTOR IN AUSTRALIA: A SYSTEMS APPROACH

by

HADI GHADERI

B.Sc. (Industrial Engineering), M.Eng (Engineering Management),

M.Sc. (Transport and Maritime Economics)

DEPARTMENT OF MARITIME AND LOGISTICS MANAGEMENT

NATIONAL CENTRE FOR PORTS AND SHIPPING

AUSTRALIAN MARITIME COLLEGE

UNIVERSITY OF TASMANIA

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DECLARATION OF ORIGINALITY

This thesis contains no material which has been accepted for a degree or diploma by the University of any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of the candidate's knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis.

Hadi Ghaderi

Date: 24th May 2016

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Date: 24th May 2016

DEDICATION

This thesis is dedicated to my parents

STATEMENT OF CO-AUTORSHIP AND THESIS CONTRIBUTION

The following people and institutions contributed to the publication of the work undertaken as part of this thesis:

Hadi Ghaderi (Candidate)	University of Tasmania, Australia
Dr Stephen Charles Cahoon (1)	University of Tasmania, Australia
Dr Hong-Oanh Nguyen (2)	University of Tasmania, Australia
Dr Jiangang Fei (3)	University of Tasmania, Australia
Dr Mohammad Reza Namazi-Rad (4)	University of Wollongong, Australia

The candidate is the primary author and contributor to the research and papers. Authors 1 and 2 are the candidate's primary and secondary supervisors respectively. Author 3 was the candidate's former supervisor, and Author 4 offered general recommendations in Paper V.

Author details and their roles:

PAPER I – Published 2015

Ghaderi, H., Fei, J. and Cahoon, S. (2015) 'The impediments to the competitiveness of the rail industry in Australia: the case of the non-bulk freight market', *Asia Pacific Journal of Marketing & Logistics*, Vol. 27, No. 1, pp. 127-145.

- Located in Appendix A-1
- Candidate was the primary author and contributed in development of framework, data collection, analysis and writing (80 per cent).
- Author Dr Jiangang Fei contributed to structure and discussion (10 per cent).
- Author Dr Stephen Cahoon contributed to editing and discussion (10 per cent).
-

PAPER II - Under review

Ghaderi, H., Cahoon, S. and Nguyen, H-O. (20xx) ‘Evaluation of impediments to the competitiveness of rail sector in Australia’, Submitted to *Research in Transportation Economics*.

- Located in Appendix A-2
- Candidate was the primary author and contributed to the development of the framework, data collection, data analysis, discussion and writing (75 per cent).
- Author Dr Stephen Cahoon contributed to discussion, development of theoretical framework, editing and critically revising the paper (20 per cent).
- Author Dr Hong-Oanh Nguyen helped to develop the required statistical model and analysis (5 per cent).

PAPER III – In press

Ghaderi, H., Cahoon, S. and Nguyen, H-O. (20xx) ‘Factors affecting the competitiveness of the Australian rail sector: a systems approach to improving service quality, Forthcoming in *International Journal of Logistics Systems & Management*.

- Located in Appendix A-3
- Candidate was the primary author and contributed to the development of framework, data collection, data analysis, discussion and writing (70 per cent).
- Author Dr Stephen Cahoon contributed to the discussion, development of theoretical framework, interpretation of work and critically improving the paper (25 per cent).
- Author Dr Hong-Oanh Nguyen contributed to the statistical analysis (5 per cent).

PAPER IV – Published in 2015

Ghaderi, H, Namazi-Rad, M. R., Cahoon, S. and Fei, J. (2015) ‘Improving the quality of rail freight services by managing the time-based attributes: the case of non-bulk rail network in

Australia', *World Review on Intermodal Transportation Research*, Vol. 5, No. 3, pp. 203-220.

- Located in Appendix A-4
- Candidate was the primary author and contributed to the conception and design of the paper, data collection, data analysis, discussion and writing (75 per cent).
- Author Dr Mohammad Reza Namazi-Rad contributed to the development of the mathematical model of the paper (10 per cent).
- Author Dr Stephen Cahoon contributed to the discussion, interpretation of work and critically improving the paper (10 per cent).
- Author Dr Jiangang Fei contributed to the discussion part of the paper (5 per cent).

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Ghaderi, H, Cahoon, S. and Nguyen, H-O. (2015) 'An investigation into the non-bulk rail freight transport in Australia', *The Asian Journal of Shipping & Logistics*, Vol. 31, No. 1, pp. 59-83.

- Located in Appendix A-5
- Candidate was the primary author and contributed to the conception and design of the paper, data collection, data analysis, discussion and writing (75 per cent).
- Author Dr Stephen Cahoon contributed to the discussion, development of theoretical framework, interpretation of work and critically improving the paper (20 per cent).
- Author Dr Hong-Oanh Nguyen contributed to the discussion part of paper (5 per cent).

PAPER VI - Under review

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- Located in Appendix A-6
- Candidate was the primary author and contributed to the conception and design of the paper, data collection, data analysis, discussion and writing (75 per cent).

- Author Dr Stephen Cahoon contributed to the discussion, interpretation of work and critically improving the paper (20 per cent).
- Author Dr Hong-Oanh Nguyen contributed to the discussion part of paper (5 per cent).

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- Candidate was the primary author and contributed to the conception and design of the paper, data collection, data analysis, discussion and writing (75 per cent).
- Author Dr Stephen Cahoon contributed to the discussion, development of theoretical framework, interpretation of work and critically improving the paper (20 per cent).
- Author Dr Hong-Oanh Nguyen contributed to the discussion part of paper (5 per cent).

We the undersigned agree with the above stated "proportion of work undertaken" for each of the above published (or submitted) peer-reviewed manuscripts contributing to this thesis:

Signed Candidate

Author 1

Author 2

Author 3

Author 4

Supervisor and head of School Declaration

We the undersigned agree with the above stated "proportion of work undertaken" for each of the above published (or submitted) peer-reviewed manuscripts contributing to this thesis:

Dr Stephen Cahoon:

Primary Supervisor

Australian Maritime College, University of Tasmania

Date: 23 May 2016

Professor Athanasios Karlis:

Director, National Centre for Ports and Shipping,

Australian Maritime College, University of Tasmania

Date: 24 May 2016

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ABSTRACT

Over the past four decades, Australia's rail sector has been in decline and has lost almost half of its previous share in the non-bulk freight market. Government policies to encourage the use of rail for the transportation of freight have been met with ongoing challenges, resulting in an urgent need to explore strategies to increase rail's competitiveness and achieve greater market share.

While there has been an increase in international research on improving the competitiveness of rail transport in the non-bulk freight markets, previous studies focussed primarily on the line-haul component of rail transport and insufficient attention was been paid to the relationship between competitiveness and the broader transport system in which rail operates. Until now, rail freight transport has not been investigated as a system comprised of different sub-systems which must be integrated into the wider multimodal freight transport environment. As a result, fragmentation of freight strategies have occurred which does not necessarily improve the competitiveness of rail transport.

This research addresses the above issues by providing a more detailed and transparent image of the key challenges faced by the rail sector in Australia. These challenges were previously ambiguous, mainly due to the paucity of empirical research and absence of stakeholder involvement. Therefore, the primary research question of this thesis is to identify and investigate strategies to improve the competitiveness of the rail sector in the Australian non-bulk freight market.

A quantitative research methodology was adopted to address the primary research question, and a conceptual model was developed following a systematic literature review. The systematic review adopted in this thesis was critical to achieving a more detailed

understanding of the key challenges facing the rail sector in Australia and to create an accurate input for the empirical stage. This approach was also beneficial to reducing the bias of available literature by applying predefined data collection strategies, inclusion and exclusion criteria and meta-analysis. Subsequently, an instrument was developed to conduct a web-based survey. The data collection was accompanied with large participation (200 potential participants with a 42.2 per cent response rate) from rail stakeholders at a national level.

By conducting exploratory and confirmatory factor analyses, the empirical results of this thesis identified four key impediments, each containing three to five factors: (i) infrastructure management, (ii) shortage of freight data and poor information sharing, (iii) interoperability and service delivery and (iv) organisational communications and commercial relationships. Four key research areas emerged when the findings of the literature review and empirical research were synthesised, resulting in further investigation being undertaken to fully address the primary research question: (i) providing strategies for service improvement, (ii) investigation of rail freight from a transport geography perspective, (iii) exploring the role of intermodal terminals in development of non-bulk rail freight market and (iv) the role of rail in the Australian port-based market. Further analysis was then conducted to address these areas. To provide strategies for improved service quality a probabilistic mathematical model was developed to evaluate the relationship between reducing transit-time and reliability as the major time-based attributes of a freight service. The model was then applied to the Australian rail freight network to provide strategies for service improvement in poor corridors. To investigate the rail freight from a transport geography perspective and to explore the role of intermodal terminals in development of non-bulk rail freight market, various secondary data sources were used with author's original analysis. Finally, primary data was collected using a survey distributed among Australian ports with intermodal activity and secondary data was collected from other sources to explore the role of rail in the Australian ports. The above investigations were accompanied by various transportation science methods. This thesis has been developed on a publication basis and the findings have been presented as seven publications, five of which have been published and two are currently under review. These publications focus on addressing the secondary research questions and objectives, all of which answer the primary research question.

This thesis makes several contributions to the industry and academia. Firstly, it provides a more transparent image of the key challenges faced by the rail sector in Australia. Secondly, it provides important recommendations for the Australian rail sector and government to make informed transportation and policy decisions, including those related to track upgrade, development of intermodal terminals interoperability and access charging systems. Thirdly, this thesis contributes to the stakeholder management and rail transportation literature by framing the concept of rail stakeholders. Fourthly and most importantly, this research contributes to the literature of transportation by developing a conceptual framework which integrates the systems approach into the competitiveness concept within a freight transportation context. This in-depth investigation into the relationship between freight service performance and competitiveness in the freight markets offers significant benefits to industry and academia when developing freight transportation improvement strategies.

EXPLANATORY NOTE ON THESIS STRUCTURE

A PhD thesis containing peer reviewed publications that explain the research undertaken during candidature is becoming popular among academia as it adds value to the candidature experience, enhances a curriculum vitae, provides more career opportunities, improves the research quality and quickly promulgates the research findings to the academic community. This model of producing a PhD thesis is well accepted at the University of Tasmania and guidelines have been provided to assist candidates and their supervisors with the preparation of a thesis that is formatted as a combination of chapters and research papers that have been published, are under review, or prepared for submission.

Accordingly, this thesis has carefully incorporated the guidelines of the University of Tasmania for producing a thesis under such format. This thesis contains four chapters to assist the reader to understand the rationale and construct of this research, followed by seven peer-reviewed papers which reflect the research outcomes. This thesis has three secondary research questions and four objectives, all of which are integrated to answer the primary research question.

In this thesis, Papers I through VII represent the work required to meet the research questions and objectives. These papers have been published (or submitted for publication), as six internationally recognised journal articles and one peer-reviewed international conference paper. As a consequence, some textual and reference overlaps occur between these papers, and the introduction and methodology chapters.

Although the papers are separated into discrete topics, its organisation has been orchestrated and integrated to be read as a single rational argument and to achieve the primary research objective of this PhD work. The decision to develop the thesis on a publication basis was made in the very early stages of the student's candidature, mainly due to the existing fragmentation and paucity of academic work in this field. This approach was critical as the study progressed in discrete stages and involved a sequence of related components. In addition, the publication-based method enabled the candidate to profoundly investigate the research problem and allowed international specialists outside of the supervisory team to review the research quality and provide feedback prior to the submission of the final thesis.

The literature review of this research was conducted separately in relation to the defined research questions and objectives. It was then presented in Chapter 1 and relevant publications. In addition, a critical review of the literature with a focus on the Australian non-bulk rail freight sector was conducted in a form of a systematic literature review and presented as a published manuscript.

The first chapter of this thesis is written as a general introduction that explains the theoretical framework needed to establish the conceptualisation of the subsequent chapters and papers. Chapter 2 explains the methodological approach applied in this thesis. Chapter 3 provides the summary of the development of papers and how they are integrated. Finally, Chapter 4 provides a holistic conclusion for the discrete papers, including the research contribution, research limitations and guidelines for future research. The research papers are subsequently provided as appendices.

LIST OF TABLES

Table 2.1	Impediments identified from the SLR	38
Table 2.2	Summary of thematic similarity analysis	40
Table 2.3	Summary of the cause-and-effect analysis	41
Table 2.4	Final table of impediments	42
Table 2.5	Summary of instrument parts	49
Table 2.6	Summary of list-based sampling	59
Table 2.7	Summary of survey response rate	61
Table 2.8	The profile of response rate in Paper II	61
Table 2.9	The profile of response rate in Paper II	61
Table 2.10	Summary of data analysis for relevant publications	66
Table 3.1	Research flow and inter-relationships between publications	74

LIST OF FIGURES

Figure 1.1	Modal split of inland freight transportation	5
Figure 1.2	Simple systems model	13
Figure 1.3	A systems approach to freight transportation	14
Figure 1.4	A systems approach to the competitiveness concept	17
Figure 1.5	Conceptual framework	23
Figure 2.1	Research strategy	35
Figure 2.2	Summary of refinement process	43
Figure 3.1	Research integration	73
Figure 3.2	Result of four EFAs on FSAs	79

LIST OF ACRONYMS

ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ARA	Australasian Railway Association
ARTC	Australian Rail Track Corporation
BTE	Bureau of Transport Economics
BTRE	Bureau of Transport and Regional Economics
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis
IA	Infrastructure Australia
NTC	National Transport Commission
PC	Productivity Commission
GDP	Gross Domestic production
FSA	Freight Service Attribute
NSW	New South Wales
NT	Northern Territory
OECD	Organisation for Economic Co-operation and Development
QLD	Queensland
SA	South Australia
SPSS	Statistical Package for Social Science
TAS	Tasmania
TEU	Twenty-foot Equivalent Unit
VIC	Victoria
WA	Western Australia
TKM	Tonne Kilometres

TABLE OF CONTENTS

DECLARATION OF ORIGINALITY 2

STATEMENT OF AUTHORITY OF ACCESSS.. 3

DEDICATION... 4

STATEMENT OF CO-AUTORSHIP AND THESIS CONTRIBUTION........... 5

ACKNOWLEDGEMENTS 10

ABSTRACT... 12

EXPLANATORY NOTE ON THESIS STRUCTURE 15

LIST OF TABLES 17

LIST OF FIGURES 18

LIST OF ACRONYMS 19

TABLE OF CONTENTS 20

CHAPTER 1: INTRODUCTION.. 1

1.1 BACKGROUND OF THE STUDY.. 2
1.2 PROBLEM STATEMENT 6
1.3 THEORETICAL FRAMEWORK 8
1.3.1 Systems theory and its applicability to the freight transport system.................. 11
1.3.2 A systems approach to the competitiveness concept 15
1.3.3 Competitiveness in the freight transport sector 18
1.3.4 A systems approach to enhancing the competitiveness of the rail sector 21
1.4 RESEARCH QUESTIONS AND OBJECTIVES... 24
1.5 STRUCTURE OF THIS THESIS 26

CHAPTER 2: METHODOLOGICAL APPROACH.. 28

2.1 INTRODUCTION... 29
2.2 RESEARCH PHILOSOPHY 29
2.2.1 Research purpose 31
2.2.2 Unit of analysis 32
2.3 METHODOLOGY STRATEGY 34
2.3.1 The systematic literature review 35
2.3.2 Refinement of the SLR findings 39
2.4 QUANTITATIVE RESEARCH DESIGN 44
2.4.1 Data collection method 44
2.4.2 Instrument design... 47
2.4.2.1 Transformation of instrument into the online platform............................ 50
2.4.2.2 Instrument pilot testing and revision... 50
2.4.3 Sampling strategy 51
2.4.3.1 Internal stakeholder stratum... 54
2.4.3.2 External stakeholders stratum 56

2.4.4 Data collection 59
2.4.5 Response rate 60
2.4.6 Data collection consideration and limitations 62
2.4.7 Data analysis 62
2.5 OTHER DATA COLLECTION AND ANALYSIS 63
2.6 RESEARCH QUALITY CONTROLS 66

CHAPTER 3: SUMMARY OF PUBLICATIONS 70

3.1 INTRODUCTION 71
3.2 RESEARCH INTEGRATION AND DEVELOPMENT 71
3.3 OVERVIEW OF THE PUBLICATIONS 74
3.3.1 Paper I - Published 74
3.3.1.1 Purpose 75
3.1.1.2 Findings 75
3.3.2 Paper II - Submitted 76
3.3.2.1 Purpose 76
3.3.2.2 Findings 77
3.3.3 Paper III – In press 78
3.3.3.1 Purpose 78
3.3.3.2 Findings 79
3.3.4 Paper IV - Published 80
3.3.4.1 Purpose 80
3.3.4.2 Findings 81
3.3.5 Paper V - Published 81
3.3.5.1 Purpose 82
3.3.5.2 Findings 82
3.3.6 Paper VI - Submitted 83
3.3.6.1 Purpose 84
3.3.6.2 Findings 84
3.3.7 Paper VII - Published 85
3.3.7.1 Purpose 85
3.3.7.2 Findings 86
3.4 SUMMARY 87

CHAPTER 4: CONCLUSION 88

4.1 INTRODUCTION 89
4.2 SUMMARY OF MAJOR FINDINGS 89
4.3 RESEARCH CONTRIBUTIONS 94
4.3.1 Contextual and industry-related contributions 94
4.3.2 Methodological, theoretical and academic contributions 96
4.4 RESEARCH LIMITATIONS 99
4.5 DIRECTIONS FOR FUTURE RESEARCH 101

APPENDICES 104

APPENDIX A-1 – PAPER I 105

APPENDIX A-2 – PAPER II 124

APPENDIX A-3 – PAPER III **153**
APPENDIX A-4 – PAPER IV **183**
APPENDIX A-5 – PAPER V **201**
APPENDIX A-6 – PAPER VI **226**
APPENDIX A-7 – PAPER VII **256**
APPENDIX B – REFINEMENT PROCESS **275**
APPENDIX C – QUESTIONNAIRE **276**
APPENDIX D – ETHICS APPROVAL **289**
APPENDIX E – PAPER II STATISTICAL DETAILS **291**
APPENDIX F – PAPER III STATISTICAL DETAILS **297**
REFERENCES **301**

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Australia is a large nation far from its international markets. The ability to efficiently and effectively undertake the freight task substantially determines its international competitiveness. The freight sector provides a significant contribution to Australia via economic growth and employment and accounts for 14 per cent of gross domestic product (GDP) (Infrastructure Australia, 2011). Therefore, a properly functioning transport market that is free of barriers and distortions is a key element of growth and competitiveness for the Australian economy (ARA, 2010).

The Australian freight activity can be categorised into two different tasks: bulk and non-bulk[1] freight. Total freight was 610.3 billion tonne kilometres (TKM) in 2011–12, of which 180.7 billion net TKM was non-bulk freight (around 30 per cent) and 429.6 billion TKM (70 per cent) was bulk freight. While the bulk rail traffic is mostly intrastate (approximately 98 per cent in net TKM), the non-bulk freight is diverse in terms of geographical distribution (BITRE, 2013). The domestic freight activity has doubled in size over the past 20 years, averaging growth of 3.5 per cent per annum, with the non-bulk (intermodal) sector having the fastest growth rate (BITRE, 2014a).

The biggest bulk haulage task is in Western Australia (WA), which is dominated by rail's movement of iron ore in the Pilbara region which represents 60 per cent of Australia's total rail freight task (and two thirds of the bulk rail freight task). Other sizeable intrastate bulk flows are recorded in Queensland (20 per cent of the total rail freight task) and New South Wales (7 per cent of the total rail freight task) where

[1] In this thesis, the words intermodal and non-bulk are used interchangeably.

there are large coal movements (BITRE, 2012). In the bulk freight task, mining companies such as BHP Billiton, Rio Tinto and Fortescue Metals Group are vertically integrated by owning and managing dedicated above- and below-rail infrastructure from their mining sites to the exporting port (BITRE, 2014b). In this freight sector, rail is the dominant mode of transport due to its economies of scale. Therefore, the competition between rail and road is not significant. The bulk rail freight task is undertaken separately from the non-bulk sector, mainly due to separate geographical markets, different regulation and policy, separate infrastructure and different stakeholders. The export of bulk freight takes place using dedicated below and above rail infrastructure and the export is undertaken in ports where no intermodal activity is undertaken (BITRE, 2014b). Accordingly, there is limited overlap in the use of infrastructure and no mutual market exists between these two sectors.

The non-bulk freight market in Australia is an example where competition between road and rail is well pronounced. The total value of the non-bulk supply chains equated to approximately two per cent of Australia's GDP in 2008[2], of which the interstate corridors comprised 61 per cent, international chains 34 per cent, and the intrastate chains five per cent (Booz & Co, 2008a). The total volume of non-bulk freight has doubled from 90.07 billion TKM in 1995 to 180.71 billion TKM in 2013 (BITRE, 2013). Of interest is that the total non-bulk freight travelling on these corridors is expected to grow much faster than the rate of population growth and the average national gross domestic product (GDP) growth (BITRE, 2010). The

[2] Transport economic-related data on the domestic freight task is not regularly generated; this figure is based on the most current data available.

continuing growth in the non-bulk freight volume is increasing the number of challenges for governments, industry and the community in Australia.

However, in spite of the significant recent and forecasted growth of the non-bulk freight task, productivity improvements of rail freight have lagged behind those of road (NTC, 2008; Visser & Hassall, 2010). Over the past two decades, rail's share has remained around only 17 per cent of the total non-bulk freight market. This has resulted in significant road freight activity across the Australian freight network. Interestingly, the highest road freight activity growth in the world was seen in Australia where truck freight activity in 2005 was more than six times greater than that in 1973 (Kamakaté & Schipper, 2009). As a result of these developments, Australia has become the most intensive user of road freight in the world[3] and has the lowest energy efficient road passenger system among members of the International Energy Association (PMTGEE, 2010; Deloitte Access Economics, 2011), which has a membership of 29 countries. International Energy Association works to ensure reliable and affordable energy for its member countries with a particular focus on energy security and economic development in transport sector.

Similarly in Europe, road continues to maintain the largest share among the inland transport modes in EU. In 2013, road transport accounted for 74.9 per cent of the total inland freight (on a TKM basis) while rail reached 18.2 per cent, slightly under the share it had in 2011 and 2012 (Eurostat, 2015). Figure 1.1 shows the modal split of inland freight transportation in the EU-8 between 2008 and 2013.

[3] When measured on a TKM per person basis.

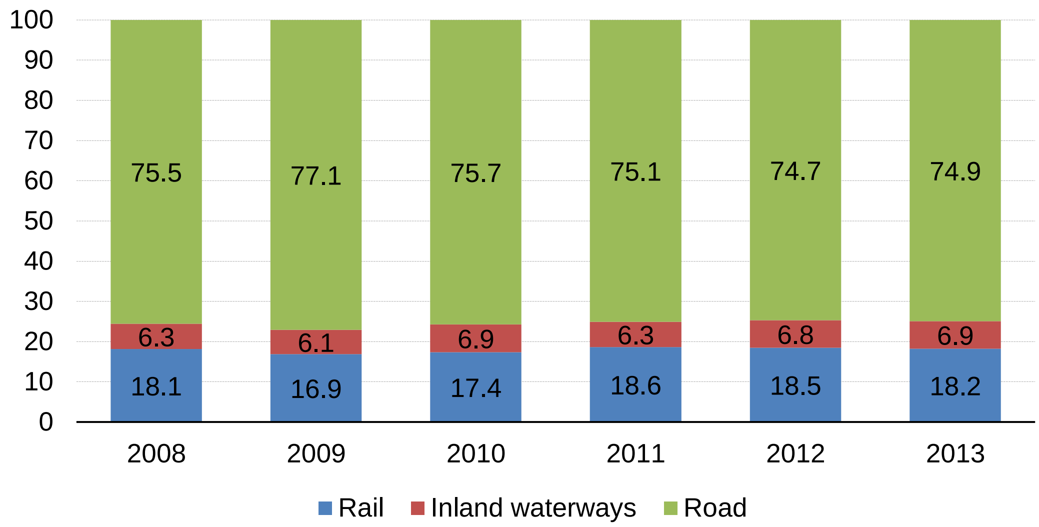

Figure 1.1 Modal split of inland freight transportation between 2008 and 2013
Source: Eurostat (2013)

The increasing role of rail in freight markets has been a focus point when developing transport policies by many governments across the world (Behrends, 2012; Peng et al., 2013). Transport policies in Europe have been pivotal in enabling a modal shift from road to rail. This is evidenced in the European Commission's (2011) White paper where a target was set that 30 per cent of freight over 300 km must shift to rail and inland navigation by 2020 and that should increase to over 50 per cent by 2050.

Australia has also begun to recognise the importance of rail as evidenced by recent government policy documents such as *Capacity Constraints and Supply Chain Performance-Intermodal* (Booz & Co, 2008a), *Multimodal Interstate Freight in Australia* (BITRE, 2010), *National Land Freight Strategy* (Infrastructure Australia, 2011) and *The True Value of Rail* (Deloitte Access Economics, 2011). The introduction of AusLink Green Papers in 2002 and 2004, for example, towards the National Land Transport Plan and funding framework of the integrated land infrastructure network were clear steps taken by the Commonwealth Government to encourage the use of rail under a viable national freight system.

Greater rail activity however must be countered by productivity and competitiveness factors, which may become hampered by the impediments of the Australian rail sector (Infrastructure Australia, 2011). According to the National Transport Commission (NTC), the impediments include infrastructure constraints, commercial barriers and inconsistent standards and regulations, all of which may result in freight managers and users not utilising the best combination of transport modes and services relative to the task (NTC, 2004; Booz & Co, 2008b). Although the notion of impediments may possibly be generalised to all the transport modes, factors exist that are unique to the Australian rail sector. Hence, the identification and evaluation of constraints that may impede rail from being an efficient mode of transport is the preliminary step to increasing the use of rail.

1.2 PROBLEM STATEMENT

The non-bulk rail sector is a complex industrial system in terms of operations, policy, regulation and structure (Woodburn, 2008; ARA, 2010). Therefore, the extent to which different actors involved in the non-bulk freight task are integrated substantially determines the performance and competitiveness of this important freight sector (Allen et al., 2010). Many mode-specific transport policies fail to bring productivity and efficiency to a transport mode, mainly because the integration of that particular transport mode into the wider transport system is neglected (Everett, 2005). This is particularly important in the non-bulk freight market where road and rail must be integrated to provide a freight service to meet the customer's requirement. Thus, to develop transportation policy and strategy to promote rail, research should investigate rail transport as a system with all its elements, its interface with other modes and the subsequent integration with the multi-modal transport system.

Despite the increasing need for greater research on transport integration (Bontekoning et al., 2004; Hesse & Rodrigue, 2004; Childerhouse et al., 2011), the literature on rail competitiveness is scarce and until now has been unsystematically generated. In other words, the competitiveness of rail transport has been investigated in relation the performance of line-haul component and not as a system in the broader freight market. The available literature is considerably fragmented, consisting of studies that are either explaining the rail's declining share in different markets from a service-level perspective (Shinghal & Fowkes, 2002; Brooks et al., 2012; Kanafani et al., 2012) or, specifically focusing on a single element of this complex system. In the first stream, research is mainly centred on different aspects of service quality such as freight rate (Shinghal, 2005), reliability levels (Kaas, 2000; Vromans et al., 2006), availability, transit-time and providing relevant strategies, whereas the second stream has more diversity due to a focus on issues such as access pricing (Everett, 2005), competition (Behrens & Pels, 2012), infrastructure management (Crozet, 2004), regulations (Cantos & Maudos, 2001; Spychalski & Swan, 2004), deregulation (Everett, 2006; Dablanc, 2009), funding approaches (Hensher et al., 2012), industry structure (Woxenius & Bärthel, 2002; Williams et al., 2005), environmental impact (Feitelson, 1994) and operational practices (Peng et al., 2013).

The operations of non-bulk rail freight involve the participation and collaboration of various players, including the above-rail operators, below-rail operators, intermodal terminal operators, ports, governments and even the road sector. Thus, providing any transport solution requires understanding the rail sector as a system that includes different sub-systems rather than an examination from the perspective of a particular player, such as the train operator, track manager, intermodal terminal operator or the regulator. Reflecting this complexity, strategies that aim to improve a particular aspect of the rail sector without examining the consequential impacts on other areas are not necessarily practical (Tsamboulas et al., 2007).

This existing fragmentation in the literature has highlighted the lack of a strong and comprehensive theoretical framework capable of incorporating the different supply chain actors involved in the non-bulk freight task into a single system. Accordingly, the performance of this system can be assessed alongside market requirements. This approach can assist government and industry in identifying, evaluating and prioritising the key industry concerns and help to make informed policy, planning and funding decisions.

1.3 THEORETICAL FRAMEWORK

Most social phenomena are complex and linked to multiple body of knowledge that belong to different disciplines of science. As a result of this complexity, better understanding of such phenomena requires a multidisciplinary approach (Jabareen, 2009). A theoretical framework is required for any research to provide both structure and boundaries (Ennis, 1999). This in turn will bring more clarity to the scope of the research.

The theoretical framework of research is related to the philosophical approach on which the research is built, and establishes the link between the theoretical aspects and practical outcomes of the research (Sinclair, 2007). Therefore, the theoretical framework justifies every step taken during the research process (Leshem & Trafford, 2007). This section describes how the development of the theoretical framework commences from a general freight transport market context to a systems approach that is used to enhance the competitiveness of the rail sector.

The development of a freight transport system is the natural response to the ever-growing needs of exchanges between individuals and societies for the movement of commodities as a part of national and global economies (Tolley & Turton, 1995). Therefore, an efficient freight transport system is a vital feature of every economy (Hesse & Rodrigue, 2004). Economic opportunities are unlikely to arise where freight transport systems are not able to answer the mobility needs and ensure access to markets and resources (Rodrigue et al., 2013). Hence, the efficiency of a freight transport system substantially determines the competitiveness of an economy.

The transport mode is a central element of every freight transport system (road, rail, sea and air). Each transport mode has a unique set of operational and commercial characteristics. Transportation modes are the means by which passengers or freight achieve mobility (Rodrigue et al., 2013). Transport modes fall into the two categories of (i) modal split and (ii) interoperability (Allen et al., 2010). Modal split refers to the extent to which a transport mode is being used to capitalise on its strength, while interoperability is related to the ability of a particular transport vehicle to operate on more than one physical network. The scope of this thesis is aligned with both modal split and interoperability, and this is linked to the competitiveness of transport modes in freight markets (Konings & Ludema, 2000). For example, the line-haul component of a non-bulk freight service is where road and rail compete for greater volumes. Moreover, the extent of rail interoperability with road is considered as a key competitiveness factor for rail transport in the non-bulk markets. This means the extent to which a transport mode meets the customer's requirement determines the modal shift and its competitiveness in the freight market.

Knowing that each transport mode has unique operational and commercial advantages which better fit the requirement of a particular freight flow, an efficient freight transport system is the one in which the users benefit from the natural advantages of each (European Commission, 2011).

As a result of changing demand from freight customers to lower freight costs and improve service quality, many governments across the world aim to promote efficiency and integration of freight transport systems by implementing the concept of intermodality. The European Commission (2006, p.21) defines intermodality as 'the efficient use of different transport modes on their own and in combination', leading to 'an optimal and sustainable utilisation of resources'. While delivering the same meaning, numerous definitions have been used to describe such freight flows (Beuthe, 2007). According to the abovementioned definition, an efficient freight transport system is derived from a combination of different transport modes or sub-systems, including road, rail, sea and air.

In many countries across the globe, especially those with a large land mass (such as Australia), rail is a key element for an integrated freight transport system due to its ability to efficiently carry large volumes over long distances and significantly lower environmental impacts on society (Brown & Hatch, 2002). Therefore, the efficiency of the rail system is a key determinant of an integrated intermodal freight system (Woodburn, 2003). This central point is the rationale for the development of the theoretical framework in this thesis. As this thesis aims to provide strategies for the Australian rail sector to enhance its competitiveness, a systems approach has been adopted to incorporate the rail sector into the wider multi-modal transport system. The systems approach is beneficial because it assists in (i) more completely identifying the interfaces of the rail sector with other supply chain actors and (ii) investigating how the rail sector can create a competitive freight service by utilisation of assets and improving processes. The following sections detail the development of the theoretical framework from the simple systems theory of management through to the construction of the conceptual framework.

1.3.1 Systems theory and its applicability to the freight transport system

Many of today's business problems are complex as they involve multiple actors with various interactions (Charlton & Andras, 2003). One of the core benefits of systems thinking is its ability to deal effectively with complex problems and to create an understanding of the level at which the results are required (Aronson, 1996).

Systems theory is regarded as one of the most useful theories in today's management practice in process-oriented organisations (Cetin & Cerit, 2010). Systems theory was developed in the 1950s by the biologist Ludwig von Bertalanffy (Von Bertalanffy, 1956). Over time, however, systems theory has been extensively embraced by various scientists in social science (Duflou et al., 2012; Kerzner, 2013; Kaput et al., 2014). Systems theory considers an organisation as a system and investigates the relationships between different sub-systems within an organisation (Kast & Rosenzweig, 1972; Erjavec & Thompson, 2014; Mason & Simmons, 2014).

To better understand systems theory, a preliminary step is to understand the concept of a system itself. There are numerous definitions available for the term system. This thesis adopts the concept of systems according to Evan (1976) which defines a system in a social environment with four basic components:

1. Inputs of various types of resources;
2. Transformations of resources with the aid of social and/or technical processes;
3. Outputs which are transmitted to other systems; and
4. Feedback effects, whether negative or positive.

The rail sector is an example of a complex system with participation from various supply chain actors and numerous interactions. Thus, Evan's (1976) approach to exploring systems is appropriate for the rail sector and capable of contributing to the constructing of the conceptual framework of this thesis.

Systems can be classified into two different types according to their interactions with their surrounding environment: the closed system and the open system. According to Parsons (2013), the closed system has rigid, impenetrable boundaries, whereas the open system has permeable boundaries between itself and a broader supra-system. Most social systems are considered open systems where the environment plays an important role in the overall performance of the system (Martin & O'Connor, 1989; Thompson, 2011). Figure 1.2 demonstrates a simple open systems model.

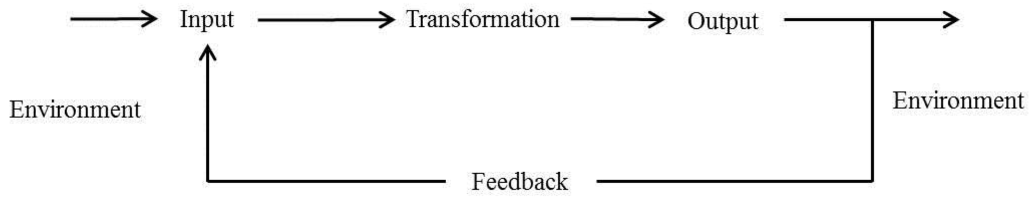

Figure 1.2 Simple systems model
Source: Littlejohn and Foss (2010)

In open systems, a system can consist of different sub-systems as interdependent components with different goals and values, and varying technical, physiological, structural and managerial characteristics (Kast & Rosenzweig, 1985; Parsons, 2013), whereas these sub-systems interdependently work towards a pre-defined objective. One major emphasis of open systems is on the throughput concept as the processing of production input to yield outcomes that are used by the external environment (Cetin & Cerit, 2010). In an open systems approach, the interaction of organisations and their internal resources with the changing external environment places a great deal of attention on growth, resource acquisition and external support (Quinn & Rohrbaugh, 1983). Other distinctive characteristics of open systems are importing of energy and information input (Katz & Kahn, 1978).

Reflecting the key features of open systems, the operational and social characteristics of freight transport systems fit to this management discipline (McLoughlin, 1969; Woxenius, 1998; Meyer & Miller, 2001; Mees, 2003). Freight systems aim to employ physical infrastructure, human resources, fuel, handling units and transport vehicles (as the inputs) using specific operational and technical practices, (as the process) to efficiently carry goods (as the outputs) for the customers under certain regulations and policies (as the external environment).

The benefit of investigating a freight transport system from a systems theory perspective is that it enables comparing of the traditional forms of analysis to understand the interrelations between its different mechanisms and the surrounding environment and to apply the concept of throughput into the freight operations setting. Due to the complexity which exists in freight transport operations, the systems approach is beneficial to effectively analysing the great number of interactions and players from an understandable level and to observe the performance of the entire transport system from a single system perspective. Figure 1.3 demonstrates a potential systems approach to freight transportation. Physical networks, transport vehicles, handling units and human resources reflect the inputs of a freight transport system, the processes are the operational practices , and finally output is a freight service provided to the customers in the market under certain regulations and policies. These three elements are surrounded by an environment referred to as the freight market and feedback exists between the elements and the environment.

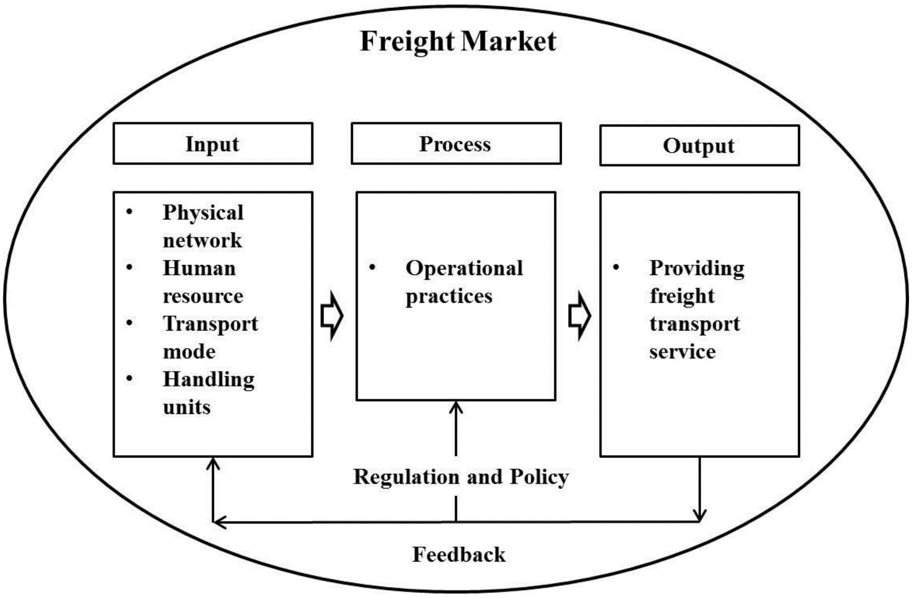

Figure 1.3 A systems approach to freight transportation
Source: author

1.3.2 A systems approach to the competitiveness concept

The extent to which the outputs of a system meet the requirements of the market as the demanding environment, determines its competitiveness. This section aims to explain the central point of the theoretical framework developed in this thesis, which is the integration of the competitiveness concept with the systems approach. Before explaining the systems approach to organisational competitiveness, a brief overview of the competitiveness concept is provided. The concept of competitiveness has been receiving increasing consideration from both academia and industry (Chikán & Chikán, 2008; Cetindamar & Kilitcioglu, 2013; Sölvell et al., 2015). This attention is mainly due to the direct relationship between competitiveness and an organisation's financial success. For example, the ability of a firm to compete in a particular market and to acquire greater market share is an indicator of financial success.

Therefore, business organisations continuously develop and implement new strategies to move from their current competitive position to a stronger one (Antony & Bhattacharyya, 2010) and this can only be achieved by enhancing the organisation's competitiveness (Dubey et al., 2014). Competitiveness is a multifaceted concept with no universal definition because its meaning varies between business organisations (Momaya, 1998).

Two main views exist to competitiveness. First, to some organisations, competitiveness is measured as their ability to convince customers to choose their products/service over an alternative (Porter, 2008). On the other hand, some organisations measure competitiveness as the ability to continuously improve their performance over competitors (Aquino, 1991; Bessant et al., 1994). The first view is mainly based on the external forces that determine the organisation’s boundaries, while looking at the organisational capabilities to enhance competitiveness has an internal basis in the second view. Feurer and Chaharbaghi (1994) define competitiveness as being principally based on the capabilities and offerings of an organisation in relation to their competitors with a continuous movement towards improving the competitive position. While the abovementioned definitions are exclusive by emphasising either the external or internal aspects of competitiveness, Feurer and Chaharbaghi (1994) embrace both. This approach to competitiveness helps organisations to improve their capabilities (internal) in order to satisfy need of the market (external). In this definition, there are four main components that exist:

1. Organisational capabilities (including input and transformation);
2. Offerings;
3. Competitors; and
4. Continuous moving towards a better competitive position.

By revisiting the simple systems theory model, similarities can be observed between the components of the holistic competitiveness concept and systems theory. Firstly, the throughput concept (Katz & Kahn, 1978) can be seen in both theories. Both aim to respond to the requirements of the external environment by relying on the internal capabilities. Secondly, the input and process components of systems theory (Seashore, 1983) are replicated as organisational capabilities in the competitiveness concept. Lastly, the output and feedback from systems theory can be interpreted as enabling continuous improvement from the competitiveness concept.

This thesis aims to suggest strategies for the Australian rail sector to enhance its competitiveness. As discussed in Section 1.3.1, the rail sector is a complex system. Therefore, approaching the concept of competitiveness from a systems theory perspective is beneficial in applying the multifaceted notion of competitiveness to a complex system (freight transport for example) at a deeper level of understanding. The proposed systems theory approach to competitiveness is a central point in developing the theoretical foundation and conceptual framework of this thesis. Figure 1.4 demonstrates an example of a systems approach to the competitiveness concept.

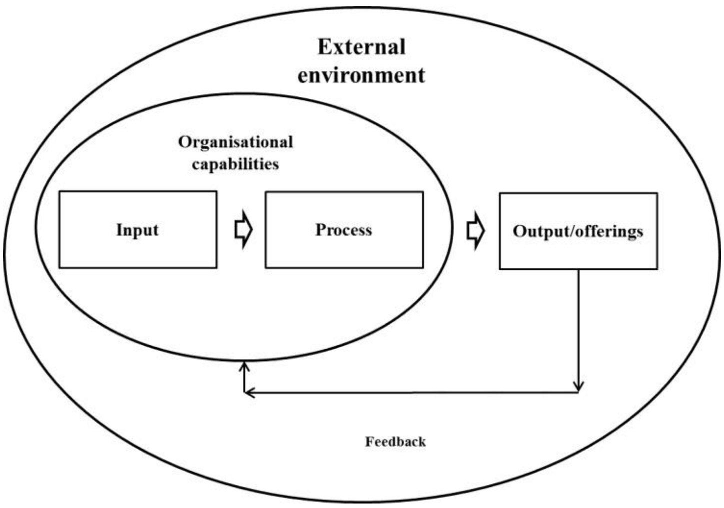

Figure 1.4 A systems approach to the competitiveness concept
Source: Author

As can be seen in Figure 1.3, the competitiveness concept is integrated with a systems approach. The input and process are grouped under organisational capabilities, while offering is the output of the system. Additionally, feedback exists between output and organisational capabilities and this system is located in a broader environment (such as a freight market).

1.3.3 Competitiveness in the freight transport sector

Competitiveness can be studied at different levels: (i) the firm, (ii) sector, and (iii) country level (Momaya, 1998). Whereas the dynamics of competitiveness at the firm and country levels have been widely discussed by Michael Porter (Porter, 1986; Porter, 1990; Porter, 1998), the concept of competitiveness at the sector level has not received similar attention (Waheeduzzaman & Ryans, 1996; Momaya, 1998; Couillard & Turkina, 2014; Latruffe, 2014; Navickas & Malakauskaite, 2015). The terms sector[4] and industry tend to be used interchangeably to define a group of firms that are active in the same segment of the economy (Bezat-Jarzębowska & Rembisz, 2013). Generally, these firms operate a similar business type, or complement each other to provide a service/product (Cetindamar & Kilitcioglu, 2013; Figiel & Kufel, 2013; Gilkinson & Dangerfield, 2013). Competitiveness at the sector level is the result of the collective actions of businesses that operate in that sector (Kaimakoudi et al., 2014). Momaya (1998) defines sector competitiveness as the extent to which a business sector:

- Satisfies the needs of customers from the appropriate combination of product/service characteristics;
- Satisfies the needs of its constituents;
- Offers attractive return on investment; and
- Offers the potential for profitable growth.

This definition differs from those provided for firms in the sense that competitiveness is derived from the collective actions of firms which are not

[4] In this thesis the term sector is used consistently, because they are being viewed as being same.

necessarily offering the same product/service, but operate within the same economic sector in order to satisfy the requirements of the end users (such as the rail sector).

This thesis is undertaken in the transportation science with a focus on the logistical perspective of competitiveness in a freight market. Thus, competitiveness is determined by the extent to which the logistical capabilities of the rail sector meet the requirements of the freight market (Tipagornwong & Figliozzi, 2014; Santos et al., 2015).

Therefore, the latter three elements of sector competitiveness explained by Momaya (1998) which are related to the constitution (for example workers in terms of safety, training and benefit programmes) and finance are excluded here. The competitiveness of the freight sector in terms of stakeholders' satisfaction (excluding customers), investment and profitability are outside the scope of this thesis and require further research from both financial and stakeholder management disciplines.

The demand for freight service is value driven (Brooks et al., 2012). The determining factor for the use of a particular transport mode is whether, and to what extent, that mode is able to adapt to the requirements of the transport industry, and in particular, freight customers (OECD, 2010). This explanation is consistent with the concept of competitiveness in terms of an organisation's capabilities to offer what meets customers' needs. A customer's choice of a freight transport service involves a complex trade-off between various monetary and non-monetary factors. Therefore, having a comprehensive understanding of these factors is necessary to develop and deliver a competitive freight service to customers. According to Porter (2008), organisations can improve their competitiveness by providing a competitive product/service. Therefore, it can be concluded that understanding the market requirements is a critical factor to enhancing competitiveness.

Over the past decade there has been increasing attention on the area of freight mode choice and identifying the key factors influencing the choice of transport mode from a customer's perspective (Meixell & Norbis, 2008; Samimi et al., 2011; Reis, 2014; Yang et al., 2014). Historically, transportation mode choice was a simple process. Nowadays, mode choice and carrier selection are becoming a part of the decision-making process in transportation management that includes identifying relevant transportation performance variables, selecting the mode of transport and carrier, negotiating rates and service levels, and evaluating carrier performance (Monczka et al., 2008; Buehler, 2011; Brooks et al., 2012; Yang et al., 2014). According to Flodén et al. (2010), understanding the factors behind the choice of freight transport mode is vital for a freight operator as the information can be used to develop marketing and transport management solutions and consequently enhance the competitiveness the freight service.

By reviewing the key literature on the key factors influencing freight mode choice (Morash & Ozment, 1996; Bolis & Maggi, 1998; Bergantino & Bolis, 2008; Meixell & Norbis, 2008; Grosso, 2011) and particularly the recent research in this field conducted by Flodén et al. (2010), Bergantino et al. (2013) and Arencibia et al. (2015), four key factors appear to influence the decision of freight customers when choosing a transport mode, these being (i) freight rate, (ii) transit-time, (iii) reliability (punctuality) and (iv) service availability. In this thesis these are called freight service attributes (FSAs). Different studies show that the these factors are recurring in most of the research undertaken on transport competitiveness and they are ranked significantly higher to other factors by the transport industry (Flodén et al., 2010).

These four factors are also consistent with the view of the Australian freight forwarding industry that broadly delineates freight types according to time-based and cost attributes (BITRE, 2009). Therefore, in this thesis the competitiveness of a freight service in the Australian non-bulk freight market is determined from these factors. This approach is pivotal in shaping the theoretical framework and methodological tools of this research for two main reasons. First, competitiveness can be measured and evaluated in terms of freight service quality. Second, strategies can be provided to improve the competitiveness of the rail service in relation to each FSA. The following section discusses how the general systems approach to competitiveness developed in Section 1.3.2 is applied to the freight transport setting.

1.3.4 A systems approach to enhancing the competitiveness of the rail sector

This section presents the conceptual framework of this thesis. In the previous sections the underlying elements for constructing the theoretical framework of this research were discussed as being: systems theory, its application to intermodal freight transport, the competitiveness concept, and a general systems theory of competitiveness. Section 1.3.1 discussed how the systems approach can be applied to a freight transport system (as shown in Figure 1.2). Based on this, the rail sector is a system competing with other transport sectors (road, sea and air) in the non-bulk freight market.

In this sense, inputs are the key element of any economic sector providing service to its customers (Salvatore, 2008). Inputs can be defined as tangible and intangible assets, whereas both can be translated into assets for a business sector (Corrado et al., 2009). In a large scale economic sector such as rail, assets are numerous and this is mainly due to the complexity of operations (Van Wee, 2007). Operations of freight trains involve various players and their assets. These mainly include below- and above-rail infrastructure, intermodal terminals, handling facilities, skilled human resources, financial resources and required technology.

The second component of the rail sector is the process. In a business sector, process is considered as the practice or know-how of employing the assets to achieve the goals (Weske, 2012). Processes are sometimes developed and implemented by the firms operating in the sector, or as the collective decision of firms under a union or association (Kast & Rosenzweig, 1972). In social systems, the processes are the policies developed and implemented by the government who control the market to ensure the economy is free of disorders (Cetin & Cerit, 2010). Likewise, in the rail system, processes mainly consist of operational practices, regulations, policy, marketing and training (Profillidis, 2014).

According to the systems approach to competitiveness developed in Section 1.3.2, assets and process are the organisational capabilities that create the outputs. In this sense, the rail sector employs both tangible and intangible assets using the operational practices under certain regulations and policies to create a competitive freight transport service for the customers. However, in order to create the service, having competitive assets and processes are essential (Momaya, 1998). Assets and process are strongly interrelated (Rüfenacht, 2012). According to systems theory, the extent to which the assets and process of a system complement each other significantly influences the quality of the output (Berrien, 1976). By looking at the rail sector as a system, better utilisation of assets using processes and under certain regulations (such as safety and policy) potentially improves the quality of rail freight services. Consequently, the feedback from the customers and competing transport modes are systematically linked back to the rail sector for improvements (Richardson, 1999).

In order to construct the underlying theory of the conceptual framework of this thesis, the systems approach was first adapted to the competitiveness concept in Section 1.3.2. This approach is beneficial to combining the input and process components of a system to organisational capabilities. In this section, the systems approach to competitiveness is applied to the rail sector. Figure 1.5 shows the conceptual framework of this thesis as the systems approach to competitiveness for the rail sector.

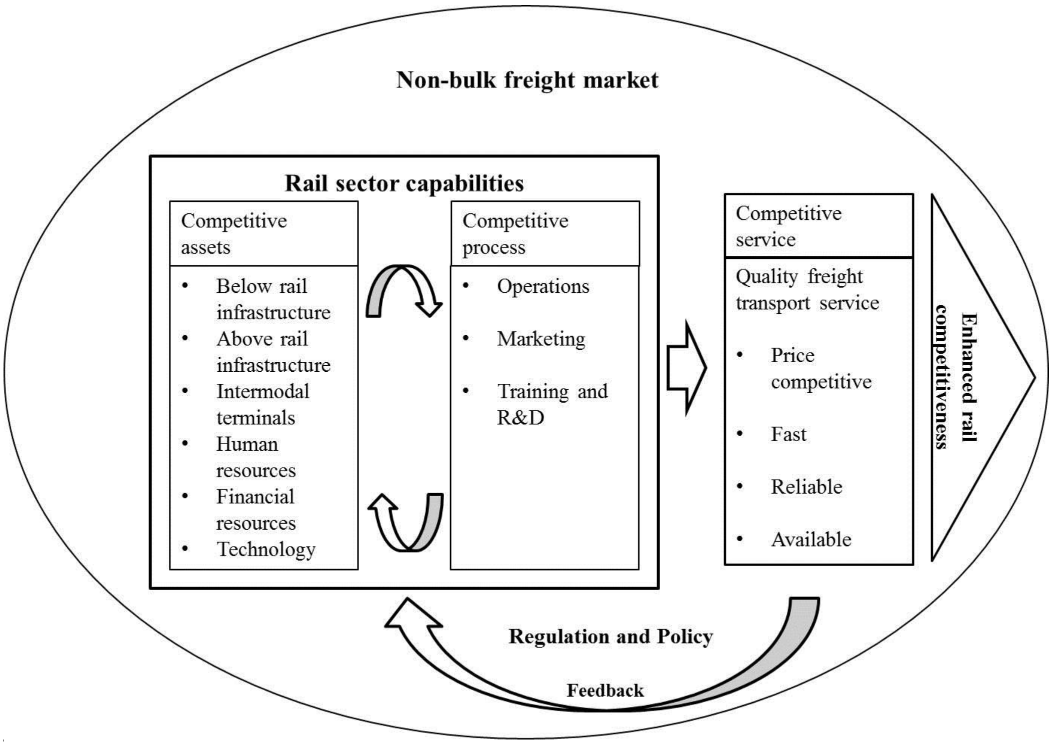

Figure 1.5 Conceptual framework of thesis: a systems approach to competitiveness for the rail sector
Source: Author

In the systems approach to competitiveness, the rail sector's capabilities aim to create a competitive service in the non-bulk freight market. As shown in Figure 1.4, assets and processes as the capabilities are interacting and the feedback from the market is returned from the sector for improvement and decision making. This conceptual framework constructs the road map to study the competitiveness of the rail sector by identifying the impediments and evaluating their impacts on the output of the sector and to provide strategies to improve the freight service quality.

1.4 RESEARCH QUESTIONS AND OBJECTIVES

The main purpose of this research is to investigate strategies to improve the competitiveness of the rail sector in the Australian non-bulk freight market by identifying and evaluating the impediments that this sector is facing. Accordingly, the following research questions have been developed.

The primary research question (PRQ):

PRQ*: What are the strategies to enhance the competitiveness of the Australian rail sector?*

According to the systems approach and conceptual framework of this thesis, the extent to which the rail sector's capabilities satisfy the freight market demand determines its competitiveness. Therefore, to adequately explore the primary research question and investigate how the internal elements of the rail sector can be strengthened to better meet the market requirements, the following secondary research questions (SRQ) are also investigated:

SRQ 1*: What are the impediments to the competitiveness of the rail sector in the Australian non-bulk freight market?*

SRQ 2*: How important are the impediments against the performance of the rail sector from the view of the key stakeholders?*

SRQ 3*: How is the competitiveness of the rail freight service affected by the current impediments?*

The SRQs in this thesis embraces the major part of empirical examination. Therefore, answering the above SRQs developed a better understanding of the poorly performing areas of the rail sector in Australia and consequently how the gap between customers' requirements and the sector's offering has been continuing to widen.

As this thesis has been developed on a publication basis, the structure and findings developed progressively in discrete stages. After analysis of quantitative data and interpreting the responses of participants to the open-ended questions, the following question raised:

"What areas of research require further investigation to better answer the PRQ?"

These identified areas included (i) investigation of strategies for improved service reliability, (ii) analysis of rail operations from geographical and spatial context inr elation to service quality, (iii) the relationship of intermodal terminal operations and rail freight activity and (iv) position of rail as a transport mode in port-based container market. On the basis of the primary research question, the under-researched areas were transformed to four research objectives to be investigated as:

Obj1: Mathematically examine how the time-based attributes of the rail freight service quality can be improved.

Obj2: Explore the rail sector from a transport geography context.

Obj3: Investigate the role of intermodal terminals in the development of the non-bulk rail market.

Obj4: Explore the current and future role of rail within Australian seaports.

By meeting the above research questions and objectives, a set of comprehensive and integrated outcomes were achieved which are reported in the following chapters. The following section explains how these outcomes are presented within the structure of this thesis. Detailed discussion of the interrelationship between the objectives and secondary research questions and how they answer the primary research question in an integrated way is provided in Section 3.2.

1.5 STRUCTURE OF THIS THESIS

This thesis follows a publication-based approach. The structure of the thesis consists of four chapters and seven papers. This introductory chapter provided the background, research problem, theoretical framework, research questions and objectives of the study. The main literature review of this thesis is prepared as a paper (Paper I) and other relevant research areas are provided in Papers II to VII. Chapter one embraces the body of knowledge on multimodal transportation and competitiveness. Paper II covers the literature of transport policy in relation to promotion of rail in non-bulk markets. Paper III aims to address the literature of transport competitiveness and an analysis of the key factors influencing the choice of transportation mode. Paper IV covers the body of knowledge related to the rail infrastructure and operational aspects of rail freight transport. Paper V provides a background on interoperability and geography of non-bulk freight transport. Paper VI includes the body of knowledge on intermodal terminals with a special focus on rail freight activity. Finally, paper VII comprises the literature of port and rail activity.

Chapter Two details the research design and methodology used in this thesis. This involves explaining the unit of analysis, target population, sampling strategy, data collection instrument and the relevant administration process, pilot testing, data collection, and data analysis methods.

Chapter Three presents a summary of the published papers and their link to the research questions and objectives. Chapter Four provides an integrated discussion of the discrete research papers and a general conclusion and recommendation in this context. Finally, the published papers are presented at the end of the thesis as appendices.

CHAPTER 2: METHODOLOGICAL APPROACH

2.1 INTRODUCTION

The previous chapter introduced the background of the research and its underlying theoretical approaches, and presented the research questions and objectives that direct this thesis. Since this thesis is structured on a publication basis, the required literature review was conducted by means of a systematic literature review (SLR) on the challenges facing the Australian rail sector (see Appendix A-1) and the body of knowledge required to investigate the research questions and objectives was summarised and presented in relevant publications (Paper II to Paper VII). This chapter presents the research methodology and research strategy adopted to address the research questions as well as other methods that were utilised to meet the research objectives.

This chapter is structured as follows: Section 2.2 discusses the research philosophy and describes the research purpose and the unit of analysis. Section 2.3 presents the research design, including the need to use an SLR approach and filtering process. Section 2.4 presents the quantitative approach applied in this thesis, including the data collection method, instrument design, sampling strategy, survey data collection and data analysis. Section 2.5 presents other data collection and data analysis methods used to meet the research objectives, plus addresses the research questions and objectives presented in the relevant papers. The final section discusses the research quality of this thesis in terms of validity and reliability.

2.2 RESEARCH PHILOSOPHY

The research philosophy is a belief that leads to the nature and development of knowledge in the research process (Johnson et al., 2007; Creswell & Clark, 2011).

The choice of a research philosophy is central to identifying and evaluating the choice of research methodology and it assists researchers shape the way they undertake their research and influences the overall research process, including the selection of the research strategy and methods for data collection and analysis (Sakalayen, 2014). According to Tashakkori and Teddlie (2010), the selection of a research philosophy is heavily influenced by the practical purpose of the research.

Creswell and Plano Clark (2011) state that four research philosophies exist: post-positivism, constructivism, participatory and pragmatism. The post-positivism approach deals with cause-and-effect and is theory laden (Trochim, 2005). Therefore, they are mainly related to a quantitative approach (Wildemuth, 1993; Ryan, 2006). Constructivism theory deals with understanding phenomena. Constructivism theory is theory generated and is associated with a qualitative approach. A participatory paradigm focuses on a process of sequential reflection and action, with a focus on political issues and collaboration and is mainly associated with a qualitative approach (Cornwall & Jewkes, 1995). The pragmatism paradigm focuses on a problem to be resolved, the consequences of an action and is a good platform for mixed methods research strategies (Garner, 2015).

This thesis adopts a post-positivism paradigm because it identifies the factors affecting rail competitiveness and examines them from a transport management perspective. The post-positivism paradigm focuses on the reported experience (for example surveys), sociological or psychological experiments (where the data must be inferred from other phenomena) and observed human behaviour as data (Dwivedi, 2009). Post-positivism methodology is about the discovery of problems (Wildemuth, 1993). Post-positivism researchers do not necessary solve the problems they set out to investigate. Research can answer questions and specify causes (problem solving). However, in the post-positivism approach, research can also be about problem setting, developing the right questions and this may lead to empirical research (Ryan, 2006). The topic and research problem of this thesis is under-investigated, implying that a post-positivism approach is beneficial to discover the right way to formulate the problem and undertake the empirical research.

As this research is in the area of business, it also accommodates the views of rail stakeholders. Therefore, considering the practical considerations of this research and the nature of the research questions, a post-positivism paradigm is adopted which is associated with a quantitative approach.

2.2.1 Research purpose

The increasing role of the rail sector in the Australian non-bulk freight market has been a focus point for the government and community. This was demonstrated in Chapter One where it was explained that relatively little academic research has been conducted on evaluating the competitiveness of the rail sector in a national context. The key reasons for rail's declining share over the last three decades are well known to the freight industry (ARTC, 2015), with the major reasons being mainly the poor service levels (BITRE, 2009). Additionally, how the service attributes of the rail service are deteriorating demands further study. The benefits from greater involvement of the rail sector in the Australian non-bulk freight task is enormous (Deloitte Access Economics, 2011), but how the rail sector can facilitate integrated transport solutions which meet the requirements of the freight industry and play a more effective role in the growing freight market also demands further study.

Therefore, the purpose of this research is to evaluate the current challenges facing the Australian rail sector in providing a competitive freight service and to propose strategic recommendations for enhanced competitiveness.

2.2.2 Unit of analysis

According to Creswell (2012), one of the primary stages in the process of developing a quantitative research methodology is to identify the people and places the researcher plans to study. This starts by asking the question as to who can provide the information that will answer the quantitative research questions, and this determines the unit of analysis (Creswell, 2013). The research purpose and research questions will define the unit of analysis (Trochim, 2005; Sakalayen, 2014). As this thesis aims to investigate the competitiveness of the Australian non-bulk rail freight sector, the stakeholders that comprise this sector are the unit of analysis. This in turn requires careful identification and classification of rail stakeholders. As far as can be determined, the concept of rail stakeholders has not been developed before.

The concept of rail stakeholders in this thesis is inspired by the port sector, mainly due to similarities in operations and governance (Everett, 2006). The concept of stakeholders has been previously discussed in the port industry (Murphy et al., 1988). Notteboom and Winkelmans (2002) categorise port stakeholders as internal and external from a port authority perspective and address stakeholders' impact on port operations and management.

The operations of non-bulk rail freight involves the participation and collaboration of various supply chain actors, including above-rail operators, below-rail operators, intermodal terminal operators, ports and even the road sector as a competitor to rail.

Understanding the dynamics of this system requires looking at the rail sector as a system with all its organisational ties and not only one player, such as train operator, track manager, intermodal terminal operator or the regulator. Therefore, this research takes a broader view of rail stakeholders to include various interest groups within the rail sector and its operational environment. Inspired by the concept of port stakeholders by Notteboom and Winkelmans (2002), this thesis classifies rail freight stakeholders as being internal and external. This framework was adopted in this thesis mainly due to its straightforward application to the rail sector. This approach however, is not based on the geographical location of stakeholders, such as those used in Notteboom and Winkelmans (2002), but relies on the nature of their business in relation to rail freight operations. In this thesis, internal stakeholders are the entities directly involved in operations of freight trains, including above-rail operators, below-rail operators (track and signalling), intermodal terminal operators, and engineering/maintenance firms. The external rail stakeholders include ports, warehousing and logistics operators, coastal shipping, the road sector, regulatory entities, government (as the policy maker) and sector representatives. This thesis therefore, is the first to ground the concept of rail stakeholders.

The Australian rail sector needs to operate commercially by providing a competitive freight service. However, the quality of the service is not only determined by the performance of train operators, but also by the extent to which collaboration exists across the supply chain. In other words, the overall efficiency of the rail sector is determined by the degree of collaboration between the internal and external stakeholders. To provide strategic recommendations to the rail sector, the involvement of all stakeholders from different levels is required. The concept of rail stakeholders developed in this thesis was essential to providing recommendations which enhance the competitiveness of the entire sector and not a particular element or division.

2.3 METHODOLOGY STRATEGY

According to Saunders et al. (2011), research strategy is the overall research plan for answering the research questions. The research strategy in this thesis starts with a systematic literature review (SLR). As discussed in the previous sections, the literature on the impediments faced by the Australian rail sector was fragmented and therefore a more systematic approach is required in order to undertake further research. Thus, the research question of the SLR was developed during the primary literature review by identifying the gaps in the research and establishing a general view of the current impediments facing by the rail sector in Australia (discussed in Sections 1.1, 1.2 and 1.4). Meta-analysis was also performed from the results of the SLR (See Appendix A-1) to better interpret the collected information. The results of the SLR was then refined in order to remove any duplication and to achieve further clarification. The research questions of the quantitative part evolved from the results of the SLR and refining process. After data collection and analysis, results were interpreted to meet the main research purpose. Figure 2.1 presents the sequence of research strategy applied in this research. The research design for the quantitative stage of this thesis is discussed in Section 2.4.

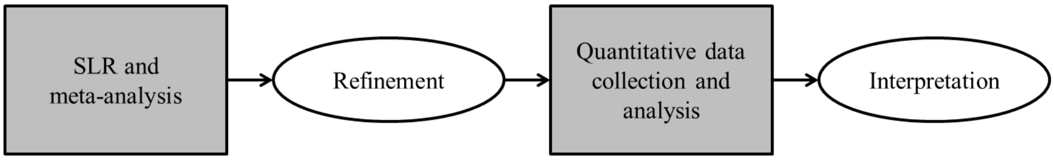

Figure 2.1 Research strategy
Source: Author

2.3.1 The systematic literature review

There has been increasing attention devoted to the systematic literature review in recent years (Kitchenham & Charters, 2007). Systematic reviews have gradually replaced the traditional narrative reviews (Kitchenham et al., 2009). According to Bryman and Bell (2011), two main reasons contribute to the emergence of systematic reviews. First, the traditional reviews demonstrate a lack of thoroughness as the researcher's agenda is often unknown and biases exist in selecting and evaluating the literature (Pickering & Byrne, 2014). Second, recently in business fields, there has been a growing need towards evidence-based solutions. Kitchenham and Charters (2007, p.5) define the SLR as 'a means of evaluating and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest'. The SLR follows a well-defined methodology which offers bias-free results and the meta-analysis provides a comprehensive investigation that conventional literature reviews are unable to achieve (Brereton et al., 2007). According to Pickering and Byrne (2014), the SLR is more comprehensive than the traditional narrative style as it assesses which different combination of locations, subjects, variables and responses have been examined by researchers, what they have found and where are the gaps. Additionally, the SLR is explicit and reproducible as it follows a quantitative approach to survey the literature. In other words, similar results should be found if the procedure is repeated (Pickering & Byrne, 2014).

Challenges arising from diverse views on impediments have led to a fragmented and biased rail transport policy-making direction which prevents the investment and improvement programs from targeting the weak parts of this important economic sector. As the topic of this thesis is a little explored area, the need for this SLR arose from the need to have an en masse and summarised picture of all reported impediments that the rail industry is facing. The SLR conducted in this thesis aimed to address the first secondary research question (***SRQ1***).

Often, SLRs include a meta-analysis component which involves using statistical methods to synthesise the data gathered from several studies into a summary (Uman, 2011). While many systematic reviews are based on an explicit quantitative meta-analysis of available data, there are also qualitative reviews which adhere to the standards for gathering, analysing and reporting evidence (Thomas et al., 2004). The meta-analysis of this SLR follows a quantitative approach to better exploit and analyse the results.

During the SLR process, 1081 studies on the Australian rail sector were identified. The search covered databases of the key transport, freight and rail organisations to ensure a comprehensive coverage. To select the studies most relevant to the research question, a tollgate criterion was then deployed with various filters, including publication date, relevancy to the non-bulk freight market and rail sector. For example, by reading the abstract, many studies were excluded as they were not focusing on the context of this thesis (focusing on passenger or bulk sectors for example). The full details of tollgate criterion and filtering process is provided in Paper I (Table 1, Figures 3 and 4). By investigating the selected studies, 43 impediments were identified by a structured data synthesis process (Table 2.1).

In the SLR, citation frequency (CF) was used to demonstrate the importance of impeding factors from the view of the stakeholders. According to Garfield (1973), the citation frequency is a measure of research activity, or of communication about research activity. If a scientific phenomenon has been cited frequently, then it is likely to be of relatively high importance and this can demonstrate the impact of this particular issue on its discipline (Yang & Meho, 2006). Accordingly, the impediments have been ranked based on their citation frequency as an indicator of their importance to the rail sector. Paper I details the process of the SLR and the relevant meta-analysis from which the following factors were derived (Appendix A-1).

Table 2.1 Impediments identified from the SLR

#	*Impediments*	Citation frequency
I_1	*Inconsistent access charging policies between road and rail*	24
I_2	*Restricted use of infrastructure and inadequate infrastructure base*	21
I_3	*Shortage of reliable data on rail freight and poor information sharing/access*	18
I_4	*Track and terminal congestion*	18
I_5	*Lack of investing, financing and subsidising policies in the non-bulk sector*	17
I_6	*Complex and uncertain interaction between different levels of government in rail transport policy*	14
I_7	*Inefficient and poor terminal design*	14
I_8	*Exclusion of full cost of externalities from pricing systems*	13
I_9	*Lack of long-term mechanism to support rail from different levels of government*	12
I_{10}	*Lack of common vision on intermodal freight and inactive role of government as coordinator*	12
I_{11}	*Inefficient terminal operation*	12
I_{12}	*Shortage of skilled human resource and low educational factors*	12
I_{13}	*Passenger priority policies in shared network*	11
I_{14}	*Rail sector is over-regulated (excessive bureaucracy)*	11
I_{15}	*Poor communication and adversarial relationships between infrastructure providers and modes in the network such as terminals*	11
I_{16}	*Lack of national rail safety regulations and standards*	10
I_{17}	*Unavailability of terminal space and access to land*	10
I_{18}	*Diverse demand and growth patterns and low volumes in regional areas*	9
I_{19}	*Different pallet and container type and size*	9
I_{20}	*Inadequacy of productive improvement initiatives for public awareness of rail benefits*	8
I_{21}	*Slow technology take up in rail industry*	8
I_{22}	*Low track quality*	8
I_{23}	*Fragmented and disjointed nature of the rail infrastructure - different gauges*	8
I_{24}	*Inconsistent public-private partnership policies*	7
I_{25}	*Lack of national rail operation regulations and standards*	7
I_{26}	*High and inconsistent terminal charges*	6
I_{27}	*Inability of rail to provide a single-mode door-to-door service and lack of coordination between road and rail*	6
I_{28}	*Lack of passing loops, passing lanes and train storages*	6
I_{29}	*Insufficient signalling facility*	6
I_{30}	*Uncertainty about capacity for growth*	5
I_{31}	*Shortage of rolling stocks and old locomotives*	5
I_{32}	*Poor inter-operability between above and below rail and between road and rail*	5
I_{33}	*Monopolistic behaviour of infrastructure owners and operator*	4
I_{34}	*Lack of integrated supply chain thinking in rail industry*	4
I_{35}	*Single tracking of the network in many parts*	4
I_{36}	*Poor history of rail industry performance(reputation)*	4
I_{37}	*Poor distribution systems*	4
I_{38}	*Diverse management of infrastructure*	4
I_{39}	*Weak maintenance systems and practice*	3
I_{40}	*Little control over the shipping lines*	3
I_{41}	*Poor customer relationship management in rail industry*	3
I_{42}	*Immobility of above rail infrastructure*	2
I_{43}	*Power of unions which influence on productivity*	1

2.3.2 Refinement of the SLR findings

The information collected from the SLR is the input for designing the quantitative research approach of this research. However, what has been collected from the literature does not guarantee a bias-free output (Collier & Mahoney, 1996; Popay et al., 1998). Therefore, in this part, various levels of analysis were conducted to provide a quality input for the quantitative stage. The sequence of this refinement included a thematic analysis, cause-and-effect analysis and clarification, each of which will be discussed in detail. Since the impediments identified in the SLR stage were collected from various sources, it was possible that a single impediment had been reported in different contexts. In order to identify these factors, a thematic analysis was conducted. Thematic analysis is one of the basic forms of categorisation strategies in qualitative research (Boyatzis, 1998; Vaismoradi et al., 2013). Thematic analysis is a powerful tool that helps researchers to identify patterns and develop themes (Tuckett, 2005; Braun & Clarke, 2006). Thematic analysis is the process of encoding qualitative data for many kinds of purposes, including approaches to detect similar themes (Boyatzis, 1998).

The purpose of the thematic analysis used in this stage is to identify the similarities among the reported impediments. Using thematic analysis, factors delivering similar meaning are clustered into one group. As the result of the thematic similarity analysis, five groups of factors were identified. The impediments with similar content were clustered in one group and a temporary code was assigned. For example, I_6 (*Complex and uncertain interaction between different levels of government in rail transport policy*) is centred on a lack of common vision from government in the non-bulk rail freight sector. Simultaneously, I_{10} (*Lack of common* *vision on intermodal freight and inactive role of government as coordinator*) was grouped under the same category. This process reduced the number of impediments by ten to 33 items. Table 2.2 presents the result of thematic similarity analysis and clustering.

Table 2.2 Summary of thematic similarity analysis

Group	***Cluster***	***Theme***	***New code***
1	I_5, I_9, I_{20}	Lack of support from government	IT_1
2	I_6, I_{10}	Lack of common vision from government	IT_2
3	I_7, I_{17}	Shortage of terminal infrastructure	IT_3
4	I_{15}, I_{33}, I_{40}	Poor relationships between players	IT_4
5	$I_{22}, I_{23}, I_{28}, I_{29}, I_{35}$	Shortage of below rail infrastructure	IT_5

Once the similar impediments are grouped in to a single factor, the next stage is to deal with the impediments that are the results of other impediments. Reflecting the post-positivism philosophy applied in this research (which focuses on the reported experience), if a cause impediment is removed the resultant impediment will be resolved. In other words, reporting both factors is repetition. To apply this approach, cause-and-effect analysis is conducted in this stage. Cause-and-effect analysis or the Ishikawa diagram is a powerful tool to identify the possible causes of a problem (Arvanitoyannis & Varzakas, 2007). While several quantitative tools have been developed to map cause-and-effect relationships, some are purely qualitative (Kenett, 2007).

In this stage, the effect impediment(s) is grouped under the cause impediment. For example, I_{16} (*Lack of national rail safety regulations and standards*) and I_{39} (*Weak maintenance systems and practice*) are the result of I_{25} (*Lack of national rail operation regulations and standards*). Cause-and-effect analysis reduced the number of impediment by seven to 26. Table 2.3 presents the summary of the cause-and-effect analysis.

Table 2.3 Summary of the cause-and-effect analysis

Effect impediment(s)	***Cause***	***Cause impediment***
Imp_2, Imp_4, Imp_{13}, Imp_{42}	Shortage of below rail infrastructure	IT_1
Imp_{16}, Imp_{39}	Lack of national rail operation standards	Imp_{25}
Imp_1	Exclusion of externalities	Imp_8

It is critical to make sure the input for the quantitative stage is free of misperception, meaning that questions must be clear enough to address one idea at a time (Litwak, 1956). Sometimes researchers may want to add together multiple questions into a single question to keep the questionnaire short. However, this can lead to double-barrelled questions which confuse the survey participants and create unreliable and biased results (Bassili & Scott, 1996). To avoid this, in this stage a careful review is conducted to remove any possible double-barrelled impediments from the list and improve clarification. As a result of this clarification, I_3 (*Shortage of reliable data on rail freight and poor information sharing/access*) was observed as a double-barrelled impediment. Availability of reliable data is essential to making transport policy decisions and operational strategies (TRB, 2003). Shortage of reliable data can result from a lack of statistical methods and data collection systems to collect and measure freight activity. However, poor information sharing and access is caused if an appropriate information technology system does not exist to link different players in the freight market (CSIRO, 2005). For this reason, I_3 is broken into two impediments (ID_1 and ID_2) to avoid confusion for the survey participants. This stage increased the number of impediments to 27.

Once the impediments are finalised in terms of content, the quality of the questionnaire text is polished to make sure participants understand the questions easily. This not only helps to achieve reliable data, it also keeps the questionnaire shorter. The result of the final impediments list with new coding is presented in Table 2.4.

Table 2.4 Final table of impediments

Former code	***Impediment***	***New code***
IT_1	Inadequate below rail infrastructure base (such as tracks and signalling)	Imp_1
IT_2	Inadequate intermodal terminal infrastructure	Imp_2
Imp_{31}	Shortage of above rail infrastructure such as rolling stocks and locomotives	Imp_3
Imp_{27}	Inability of rail to provide a single-mode door-to-door service	Imp_4
Imp_{32}	Poor inter-operability between different players in the non-bulk freight market	Imp_5
Imp_{25}	Lack of national rail operations standards	Imp_6
Imp_{37}	Poor freight distribution systems	Imp_7
Imp_{19}	Different types of pallets and containers	Imp_8
Imp_{26}	High terminal charges	Imp_9
Imp_{11}	Inefficient terminal operations	Imp_{10}
Imp_{38}	Diverse management of infrastructure	Imp_{11}
Imp_8	Inconsistent charging policies between road and rail for accessing their infrastructure	Imp_{12}
IT_5	Lack of a common vision for the non-bulk rail freight sector between different levels of government	Imp_{13}
IT_3	Lack of support from different levels of government for the non-bulk rail freight sector	Imp_{14}
Imp_{24}	Inconsistent public-private partnership policies	Imp_{15}
Imp_{30}	Uncertainty about capacity for growth	Imp_{16}
Imp_{18}	Diverse demand and growth patterns	Imp_{17}
ID_1	Shortage of reliable data on rail freight	Imp_{18}
ID_2	Poor information sharing and access in the non-bulk rail industry	Imp_{19}
Imp_{12}	Shortage of skilled human resources	Imp_{20}
Imp_{14}	Over-regulation of the rail sector	Imp_{21}
Imp_{21}	Slow adoption of technology in the rail industry	Imp_{22}
Imp_{34}	Lack of integrated supply chain thinking in the rail industry	Imp_{23}
Imp_{36}	Poor performance history of the rail industry	Imp_{24}
Imp_{41}	Poor customer relationship management in the rail industry	Imp_{25}
Imp_{43}	Trade union influence on productivity	Imp_{26}
IT_4	Adversarial relationships between players in the non-bulk freight sector	Imp_{27}

Figure 2.2 summarises the refinement process in different stages with the relevant changes in the number of impediments. Appendix B provides the summary of this refinement process.

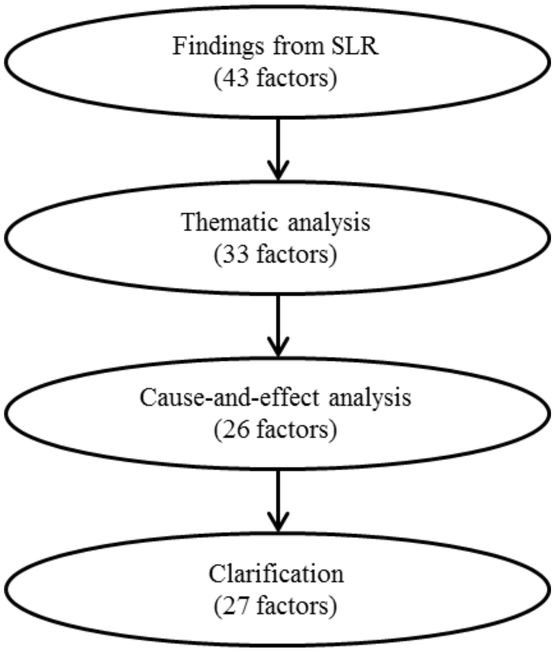

Figure 2.2 Summary of refinement process of impediments
Source: Author

As the topic of this research is little explored, the SLR found a lack of academic literature on the impediments faced by the Australian rail sector. Despite various concerns that the government and industry have on this important economic sector, no national study was identified that systematically explores the key impeding areas against competitiveness of the rail sector. For this reason, a SLR was essential to accommodating and exploring various aspects of this topic. As the identified factors from the SLR were generated by different stakeholders, refinement was central to creating consistency. Without the refinement process, developing a bias-free and easy-to-understand input for the quantitative stage was unlikely to be achieved. Using the SLR, the ***SRQ1*** was answered by identifying the impediments to the competitiveness of the Australian rail sector. The result of the input was consequently used to develop the quantitative research method and in particular, the questionnaire. The following section discusses the quantitative approach adopted in this thesis to answer the remaining secondary research questions (***SRQ2*** and ***SRQ3***).

2.4 QUANTITATIVE RESEARCH DESIGN

Easterby-Smith et al. (1991, p. 21) define the research design as the 'overall configuration of a piece of research'. The development of the research design is considered the most challenging part of conducting research as it provides the roadmap for the practical parts of the research (Yin, 2009). The research design is responsible for guiding the ethical considerations, constructing the sampling strategies, and directing the data analysis and collection in order to answer the research questions (Cooper & Schindler, 2003; Creswell & Clark, 2011).

This section presents the different stages undertaken to collect and analyse the quantitative data required to answer ***SRQ2 and SRQ3***. This section includes justifying the data collection method, instrument design and transformation, sampling strategy, data collection and data analysis.

2.4.1 Data collection method

Data collection methods are heavily influenced by the types of information needed (Yin, 2009). Two models exist to gather primary data where: (i) the researcher observes conditions, behaviour, events, people or processes, and (ii) the researcher communicates with people about various topics, including the participant's attitude about a particular topic (Cooper & Schindler, 2003). This research focuses on surveying the attitudes of different stakeholders on a range of factors impacting on the competitiveness of the rail sector in Australia. Therefore, a communicative approach is suitable for this research to investigate the view of stakeholders on the impeding factors. The collection of data to address this implication is through a survey instrument, mainly because it is capable of collecting data from a large number of respondents (Blair et al., 2013) scattered throughout a vast geographical area (Rossi et al., 2013) in a cost-effective manner (Bethlehem & Biffignandi, 2011).

There are two major forms of surveys: cross-sectional and longitudinal (Rindfleisch et al., 2008). In a cross-sectional survey design, the researcher collects data at one point in time. Cross-sectional surveys include: examining current attitudes and understanding practices, comparing two or more educational groups, measuring community needs, evaluating a program and national survey (Creswell, 2012). Cross-sectional surveys are popular data collection tools for researchers in the business management discipline to collect the view of people on a particular phenomenon (Rosenberg et al., 2012; Dimairo et al., 2015). This type of survey enables the researcher to explore a phenomenon at a point of time (Rindfleisch et al., 2008). In other words, this approach provides insights on the attitude and behaviour of participants towards a situation at one particular time. Reflecting the purpose of this research, a cross-sectional survey is used to examine the current impediments facing the Australian rail sector from the view of key stakeholders.

Although several types of surveys exist, researchers typically collect data through either questionnaire or interview (Cooper & Schindler, 2003). To choose between a questionnaire and interview, the researcher must answer the question of who completes or records the data on the instrument: the participant or the researcher

(Creswell, 2012). As rail stakeholders are located across the country, conducting interviews was not possible, mainly due to the practical considerations of time, cost and logistics of accessing interviewees. Therefore, a self-administrated questionnaire was selected to effectively reach the target population and increase the response rate (Labonté et al., 2012).

In order to increase both the sample size and response rate, an electronic questionnaire method was selected for the data collection (Simsek & Veiga, 2001; Ahern, 2005). This decision was influenced by two major reasons: (i) convenience and fast distribution of the instrument among target population and (ii) to remove the risk that individuals decide not to return the instrument (Fricker, 2008; Bethlehem & Biffignandi, 2011). A key issue for the success of web-based surveys is the internet coverage. According to the Australian Bureau of Statistics, there were approximately 12.8 million internet subscribers in Australia at the end of June 2015 (ABS, 2015). This explains the facility for wide coverage and fast internet access for the Australian rail stakeholders contacted in this thesis. The discussion related to the online survey platform and pilot testing is presented in Section 2.4.2.

Sampling control during data collection is also an important measure as it provides a clear understanding of sample size and it controls false identities, which is common in web-based surveys (Simsek & Veiga, 2001). According to Bethlehem and Biffignandi (2011), the application of stratified sampling (adapted in this thesis) for web-based surveys is practical to gain more control over sampling process.

2.4.2 Instrument design

Research on self-administrated surveys (Labonté et al., 2012; Christensen et al., 2013) suggest that the design of the instrument is extremely important in reducing biased answers from respondents (Couper et al., 2001). Designing a questionnaire instrument is a challenging and complex task as it should first be considered whether a survey instrument is valid and reliable to measure variables (Creswell, 2012). Moreover, the instrument should be developed into a logical, clear way that flows easily and keeps the respondent motivated to continue the survey (Baruch & Holtom, 2008).

The development of the questionnaire started with revisiting ***SRQ2*** and ***SRQ3*** to transform the general research questions into specific measurement questions (Cooper & Schindler, 2003). The transformation process depends on the type of data required to answer the research question. The type of data also determines the analytical procedures that must be performed during data collection and analysis (Sudman & Bradburn, 1983).

The aim of ***SRQ2*** was to examine the importance of the impediments against the performance of the rail sector from the view of the key stakeholders. In order to measure the attitude of stakeholders to the impediments, interval data using Likert scale was used. Use of interval data is essential here to measure the difference between two values (Miller & Yang, 1997). The Likert scale is a useful tool for measuring interval data (Cooper & Schindler, 2003). To answer ***SRQ2***, a seven point Likert scale of level of importance (Vagias, 2006) was used to gain a more comparable data for the statistical analysis (Gil & González-Rodríguez, 2012). The details of data collection method for ***SRQ2*** is provided in Paper II (see Appendix A-2).

The third secondary research question (***SRQ3***) investigates the impact of impediments on the abovementioned FSAs. As discussed in Section 1.3.3, the competitiveness of a freight service is determined from various monetary and non-monetary FSA. In this thesis, these include freight rate, transit time, service reliability and service availability. Therefore, it was critical to provide a scale for the participants to express their view on the relationships between the impediments and FSAs. Therefore, a five point Likert scale of level of influence (Vagias, 2006) was used to measure this relationship. This decision to use a five point scale for ***SRQ3*** was made mainly because it provides a faster response time and easier rating by the respondents. The details of data collection method for ***SRQ3*** is provided in Paper II (see Appendix A-3)

In order to fully exploit the research questions, collect supporting information, develop a logical survey flow and ensure reliability of data collection with a high response rate, an in-depth questionnaire was developed using both structured and unstructured questions in seven parts, each of which were designed to meet a particular research deliverable:

1. Information sheet
2. Consent section
3. Information on organisations' profile *(Part A)*
4. Organisational decision making and freight service attributes *(Part B)*
5. Importance of impediments from the perspectives of stakeholders *(Part C)*

6. Assessing the influence of impediments on the service attributes *(Part D)*
7. Open-ended questions *(Part E)*
8. Respondent's profile *(Part F)*

To obtain ethics approval for social science research at the University of Tasmania, it is obligatory to provide an information sheet and consent form to the participants prior to data collection. The National Statement on Ethical Conduct provides ethics guidelines for any research involving human participants (Australian Government, 2007). This research was approved by this authority with its ethics reference number being H0014314 (Appendix D).

Therefore, these forms were provided in the beginning of the questionnaire. Table 2.5 summaries the type of data, measurement approach, question structure and their relation to the research questions.

Table 2.5 Summary of instrument parts

Part	*Number of questions*	*Type of data*	*Measurement approach*	*Question structure*	*Relation to RQ*
Part A	1	Nominal*	-	Structured	Supporting information
Part B	4	Interval	Formative	Structured	Supporting information
Part C	28	Interval	Formative	Structured	RQ2 and Obj4
Part D	124	Interval	Formative	Structured	RQ3
Part E	6	Descriptive	Thematic	Unstructured	RQ2, RQ3 and Obj4
Part F	4	Nominal	-	Structured	Supporting information

*Nominal data in this research provides supporting information and no measurement analysis was conducted on them.

The paper-based version of the final questionnaire is provided in the appendices (Appendix C).

2.4.2.1 Transformation of instrument into the online platform

Typically, there are two forms of communication instruments: paper-based (mailed questionnaire) and electronic questionnaire (Simsek & Veiga, 2000). With increased access to the internet, an electronic form of questionnaire is becoming popular between academia and industry (Andrews et al., 2003). Electronic surveys are faster compared to mail surveys and the costs associated with distribution of surveys and preparation of data for analysis are much lower with the electronically delivered surveys (Shannon & Bradshaw, 2002). According to Crawford et al. (2005), navigation through the survey should be consistent throughout the survey and should be based upon action buttons which are different to any other response input element. In this research, SurveyMonkey was employed due to several reasons, including easy question creation and adaptability to the design limitations, integration with the Statistical Package for Social Science (SPSS) for data analysis and being user-friendly for both researcher and respondents.

2.4.2.2 Instrument pilot testing and revision

Cooper and Schindler (2003) suggest the use of pilot testing to avoid potential errors in the final instrument. This stage helps to determine if the respondents in the target sample are capable of completing the survey and that they can understand the questions (Blair et al., 2013; Rossi et al., 2013). Consequently, changes will be made on different parts of the instrument based on the feedback received from the pilot testing. Pilot testing of the survey used in this thesis was conducted at three levels of professional, academic and multimedia to provide error-free and smooth instrument.

The first stage involved a group of eight individuals with a logistics and transportation background from both academic and industry sectors to evaluate the technical information provided in the survey. To execute the second round of pilot testing, six academics were involved from the Department of Maritime and Logistics Management at the Australian Maritime College, an institute of the University of Tasmania and SMART Infrastructure Facility from the University of Wollongong. The individuals participating in this stage all have logistics, transportation, transport policy or infrastructure planning backgrounds. The third phase was conducted after transformation of the paper-based instrument onto the online platform. After the transformation process, one multimedia professional was contacted from the University of Tasmania to assess the user friendliness of the web-based survey. After careful consideration, the constructive comments were applied to the final instrument before distribution among participants.

2.4.3 Sampling strategy

In social science, sampling is the procedure of choosing units (people or organisations for example) from a population of interest. By investigating the sample, the researcher may fairly generalise the results back to the population (Trochim, 2005). Therefore, for many research explorations the need to sample is one that is almost invariably encountered in quantitative research (Bryman & Bell, 2011). According to Wilkinson (1999), a sampling procedure must be carefully conducted to represent the entire population.

Two main sampling approaches exist: probability and nonprobability sampling (Fricker, 2008). The decision of choosing a sampling approach depends on the amount of accuracy that researchers seek for their studies (Daniel, 2011). Simple random sampling is the most basic type of probability sampling. In this approach the participants are selected for the sample in such way that every unit from the sample has an equal probability of being selected from the population (Rao et al., 1962). However, this method is often impractical as (1) it requires a complete population list; (2) it fails to employ all the information about a population; and (3) is costly in terms of money and time (Cooper & Schindler, 2003).

In probability sampling, the researcher selects units from the entire population who are representative of the population. Therefore any bias in the population will be equally distributed among the individuals chosen to take part in the survey (Cooper & Schindler, 2003). This is one of the most rigorous type of sampling approaches in quantitative research because the investigator can claim that the sample is representative of the population and, as such, can make inferential generalisations to the population (Creswell, 2012). Stratified sampling is a type of probability sampling which is more economical and provides a desired precision (Fricker, 2008). In stratified sampling, the population is divided into characteristics of importance in the research called strata. Accordingly, the population is randomly sampled within each stratum (Collins et al., 2007).

According to Couper (2011), a list-based stratified sampling approach can be used for high coverage and to obtain more control over the sample, especially when the participants are distributed throughout a vast geographical area. List-based stratified sampling is more accurate than simple random sampling, and it generates a more representative sample with respect to each stratum. Therefore, to obtain homogenous sub-groups (Collins et al., 2007) and capture the special elements of each stratum, a list-based (Fricker, 2008) stratified sampling strategy was employed in this research.

The individuals targeted in this research were the stakeholders of the Australian non-bulk rail freight sector. The population was comprised of internal rail stakeholders who are directly involved in operations of freight trains and the external rail stakeholders (also called supporting rail stakeholders), whose involvement is necessary for the rail sector to remain operational in the freight market (as discussed in Section 2.2.2).

The rail stakeholders were divided into the following two strata to ensure better control over the representing sample:

- Stratum 1: internal rail stakeholders, including above-rail operators, below-rail operators (track and signalling), intermodal terminal operators, and consultation/engineering/maintenance firms.
- Stratum 2: external stakeholders, including ports, warehousing and logistics operators, coastal shipping, the road sector, regulatory entities, government (as the policy maker) and sector representatives.

In order to ensure an optimum representative sample, these two strata were not overlapping in terms of operations and the individuals within the groups are homogeneous (Bethlehem & Biffignandi, 2011; Sakalayen, 2014). As the sample for this thesis is diverse and distributed over a wide geographical area, it is essential to establish a sampling frame. Various sources were used to establish the sampling frame. These sources mainly included the following major rail and freight related directories:

- The Australian Rail Directory (www.raildirectory.com.au)
- Industry Capability Network Gateway (www.rail.icn.org.au)
- Rail Page Australia (www.railpage.com.au)
- Australian Government Directory (www.directory.gov.au)
- BITRE (www.bitre.gov.au)
- Companies' websites
- Company360 (www.company360.com.au)

The detailed process of establishing the sampling frame for each stratum is explained in the following sections.

2.4.3.1 Internal stakeholder stratum

For the internal stakeholders, operations managers were targeted. The operations manager coordinate, manage and monitor the operations of an organisation. Additionally, they are the people most involved in decision making and capable of understanding the logistical considerations of rail operations. Therefore, operations managers are the appropriate people to participate in the survey in terms of knowledge and experience.

1) Above rail operators

Due to the importance of above-rail operations and to establish a national understanding of the impediments, a State-based approach was taken. In this approach the above-rail operators and their operating branches in all the Australian States and territories were included in this stratum. This equated to 51 potential respondents.

2) *Below rail operators*

Below rail operators are responsible for the management and operations of Australia’s railway system, including the tracks. The Australian Rail Directory provides a comprehensive list of the below-rail operators, including the interstate, intrastate and port-based sections. This sample equated to 14 potential respondents.

3) *Intermodal terminal operators*

Intermodal terminals play an important role in the non-bulk freight market by being the points of exchange and creating integration between different transport modes (Corry & Kozan, 2006). For this group, a rigorous web search was conducted to identify the total population size. A total of 46 intermodal terminal facilities were identified, ranging from small regional (intrastate) intermodal terminals to large port-based terminals with operations stretching across the globe. Although some of these facilities belong to or are managed by one operator, they face different challenges (such as different container and gauge size) across the nation.

4) Consultation/engineering/maintenance firms

The operations of rail are complex and require a high level of engagement from various actors involved in designing and maintaining infrastructure and other supporting systems. For this list, eight participants were selected from each category of consultation, engineering and maintenance (24 in total). The participants were chosen based on companies with the highest revenue. In order to identify the top eight high-revenue firms, Company360 was used as it is the most in-depth business information search engine on Australia’s leading 50,000 private and public companies (Company360, 2014).

2.4.3.2 External stakeholders stratum

Selecting respondents for the external stakeholder stratum is more complex than the internal stakeholder stratum mainly due to the diversity of their business focus. In alignment with the internal stakeholder stratum, operations managers were selected from those organisations whose core business is linked to freight operations (freight forwarders, road haulage, coastal shipping, warehousing and third-party logistics providers and port authorities). For the stakeholders involved in making regulations and policy, senior managers with influence on the rail sector were selected.

1) Freight forwarders

Freight forwarders play an important role in ensuring the smooth and safe delivery of goods across the supply chains in Australia (Shipping Australia, 2011). Their role is even more prominent in the non-bulk market where integration between different transport modes is critical. For this category the top 30 high-revenue freight forwarders were identified from the Company360 website. A rigorous search of the potential freight forwarders websites resulted in 13 respondents being excluded as they did not have any direct business with the rail sector, thus reducing the sample size to 17.

2) Road haulage

The number of players in the road sector is large, mainly due to the low amount of investment required to enter the market (BITRE, 2009). This category was studied as the competitive behaviour of the road to rail could heavily impact the survey results. Therefore, the ten largest national road operators were selected based on their revenue and their daily business with the rail sector.

3) Coastal shipping

For this list, four coastal shipping companies are actively involved in the Australian non-bulk freight market. These companies were identified and contacted. The operational area of these companies is mainly limited to carrying goods between Port of Melbourne and Australia's island State, Tasmania.

4) Warehousing and value-adding logistics service

The number of third-party logistics operators (such as warehousing operators) involved in the non-bulk freight task is large. After a web search, two operators were identified with facilities within an intermodal terminal with involvement in terminal handling operations. These operators are capable to participate in the survey and to evaluate the impediments.

5) Regulatory, advisory and policy maker

Governments express their views through different channels such as their statutory bodies. These entities are responsible for developing transport policy, establishing regulations and providing advice in the rail sector. Therefore, they play an important supporting role in the efficient operations of the rail sector. The stakeholders involved in this stratum can be categorised as follows:

- Transport and freight-related bodies
- Infrastructure-related organisations
- Trade and commerce-related entities
- Regulatory and safety-related organisations

- Government research and consultancies

Some of the stakeholders are federal organisations, while in some States, various organisations developed over time resulting in them having a growing influence on rail policy and regulation. After a search for these stakeholders, the process resulted in 28 potential participants. This number shows the full sample size of this list. Knowledge about rail operations was a critical factor when developing this list.

6) **Rail sector representative**

There are also representative bodies of the rail industry in Australia. These entities are actively involved with government in the development of rail policy to ensure the industry's opinions are represented. Therefore, their views are considered valuable for this research. After a search, four representatives were identified as being suitable to participate in the survey.

7) **Port authorities**

The operation of rail is extended into ports. In other words, ports are considered as key external rail stakeholders. The relationship between rail and ports can be defined in (i) terminal handling and (ii) below-rail operations. After searching the website of the Australian ports, 13 ports with intermodal activity were selected to participate in this research.

The rationale applied for establishing the sampling frame and participant selection was the likelihood that selected organisations would have people to provide reliable information, accessibility and willingness to participate and finally to avoid collecting biased data (Creswell & Clark, 2011; Sakalayen, 2014). Table 2.6 shows the number of identified respondents for each list.

Table 2.6 Summary of list-based sampling

Sector	***Sector participants***	***Population of sector response***
Above-rail operation	51	24
Below-rail operation	14	6.6
Intermodal terminal operation	46	21.6
Consultation and engineering	24	11.3
Freight forwarding	17	8
Road haulage	10	4.7
Coastal shipping	4	1.8
Warehousing and logistics	2	1
Regulatory	28	13.1
Representative	4	1.8
Ports	13	6.1
Total	*213*	*100%*

2.4.4 Data collection

Two recruitment methods were used for the data collection. First, an email was sent to the participants whose email address and position were available from the organisation's website. The email invited them to participate in the study. As an incentive, a previous conference publication was provided (a short version of Paper IV), as well as a summary report of the findings (upon the participant's request). The invitation email also contained a participant information sheet and the opportunity to provide consent was provided at the beginning of the online survey. The email invitation also provided the link to access the survey.

The second approach was used for the participants whose email address was not publicly available. In this method, the participant's LinkedIn profile was identified. Professionals are increasingly using LinkedIn to liaise with one another and share vital business connections in their respective industries (McCorkindale & DiStaso, 2014). This provides an excellent opportunity for researchers to increase the response rate by identifying and reaching potential respondents. After identifying the respondents, a short invitation message was then sent through a private message with the link to the survey.

In order to increase the response rate, two reminder emails were also sent at ten-day and 20-day intervals following the first invitation. As the survey was anonymous the reminder emails were sent to all the participants. Data collection started on 17 August 2014 by sending the invitation email to the identified participant and ended on 17 September 2014 by closing the survey. The detailed response rate and descriptive statistics of the survey for ***SRQ2*** and ***SRQ3*** are provided as Paper II and Paper III (Appendix A-2 and A-3 respectively).

2.4.5 Response rate

As discussed in Section 2.4.2, Part C of the survey was responsible for providing answers to ***SRQ2***, while Part D was designed to answer ***SRQ3***. Part D included more technical questions which required specific knowledge on rail management and operations. Therefore, respondents without the essential knowledge and expertise could skip this part and proceed to the next sections of the survey. Accordingly, different sample sizes were developed from Part C and Part D. Part E of the survey was also designed to explore the role of rail in the Australian port-based market (***Obj4***). Table 2.7 presents the response rate for each part relevant to ***SRQ2, SRQ3*** and ***Obj4***.

Table 2.7 Summary of survey response rate

Survey section	*Participant sample*	*Number of Respondents*	*Response rate*	*Contribution*
Part C	200	84	42.2	SRQ2
Part D	200	66	33	SRQ3
Part E	13	9	69.2	Obj4

The details of the response rate for each part of the questionnaire are presented as Table 2.8 and Table 2.9 in below.

Table 2.8 The profile of response rate in Paper II

Sector	*Sector participants*	*Sector respondents*	*Response rate*	*Sector response portion*
Regulatory and policy making	28	18	64.3	21.4
Above-rail operation	51	18	35.3	21.4
Terminal operation	46	13	28	15.4
Consultation and engineering	24	12	50	14.3
Freight forwarding	17	10	59	12
Below-rail operation	14	7	50	8.3
Coastal shipping	4	2	50	2.4
Representative	4	2	50	2.4
Road haulage	10	1	1	1.2
Warehousing and logistics	2	1	50	1.2
Total	200	84	-	100

Table 2.9 The profile of response rate in Paper III

Sector	*Sector participants*	*Sector respondents*	*Response rate*	*Sector response portion*
Regulatory and policy making	28	14	50	21.3
Above-rail operation	51	15	29.4	22.8
Terminal operation	46	10	21.8	15.1
Consultation and engineering	24	10	41.6	15.2
Freight forwarding	17	7	41.2	10.6
Below-rail operation	14	5	35.7	7.5
Coastal shipping	4	2	50	3
Representative	4	1	25	1.5
Road haulage	10	1	10	1.5
Warehousing and logistics	2	1	50	1.5
Total	200	66	-	100

2.4.6 Data collection consideration and limitations

The data collection of this thesis was designed to ensure the anonymity of the respondents. While anonymous surveys have numerous advantages, they may also trigger biased responses from participants (Bryman & Bell, 2011). The decision to use anonymous survey was made to promote a greater response rate, practical considerations of this research (focusing on a narrow specialist population for example) and experience gained from the pilot testing. In order to minimise the risk of biased responses, various strategies were implemented. First, the selection of participants was undertaken. Basic information about potential participants was collected to make sure the person is knowledgeable and experienced in the field. Accordingly, a relevant manuscript (conference version of Paper IV) published by the candidate was attached to the invitation letter to motivate the participant.

2.4.7 Data analysis

Data analysis in this research consisted of examining, categorising, tabulating and testing the collected data to address the initial propositions of the study (Yin, 2010). A mixture of descriptive and analytical statistical methods was used to address the remaining secondary research questions. This section provides a brief discussion of the data analysis approaches used to address ***SRQ2*** and ***SRQ3***. The detailed analysis is provided in Paper II (Appendix A-2) and Paper III (Appendix A-3) respectively.

The data analysis for ***SRQ2*** includes descriptive statistical analysis and inferential statistical tests. The inferential approach comprises an exploratory factor analysis (EFA), followed by a confirmatory factor analysis (CFA) (Curran et al., 1996; Markus, 2012). The use of both EFA and CFA is preferred as it enables an effective approach to identifying and analysing the underlying factors from many variables provided in the questionnaire (Thompson, 2004). Accordingly, this statistical approach was beneficial to better ascertaining the key impediments facing the Australian rail sector. A detailed analysis of the statistical techniques conducted to answer ***SRQ2*** is provided in Appendix E.

SRQ3 deals with evaluating the impact of impediments on the freight service attributes. The data analysis to answer this question involved descriptive presentation and inferential analysis of the data. The inferential approach consists of conducting an EFA for each FSA. The reduction of a large number of factors to an adequate number with a clear factor structure was the ultimate aim of factor extraction using EFA (Pallant, 2013). This provided the opportunity to understand which impediments are more influential on each FSA. Paper III (Appendix A-3) presents the publication that is relevant to this research question and also explains the detailed data analysis. Appendix F provides the detailed statistical figures.

2.5 OTHER DATA COLLECTION AND ANALYSIS

Data collection in this research was reliant on (i) the nature of the industry problem and (ii) type of research questions (Cooper & Schindler, 2003). Marshall and Rossman (2006) state that the fit between the data collection methods and the purpose of the study is a critical issue. The previous sections presented the various methodological approaches applied in this thesis to answer the secondary research questions (***SRQ1, SRQ2 and SRQ3)***. As discussed in Section 1.4, after undertaking the empirical examination, four key areas were identified which required further research in order to provide explicit and comprehensive answers to the primary research question (***PRQ***). Accordingly, four objectives were developed to cover the under-researched areas. Meeting these objectives however, required different approaches of data collection and analysis. In this section the other forms of data collection and analysis required to meet the four objectives of this research are summarised. As this thesis is based on a publication basis, the details of data collection for each objective are provided in the relevant papers.

Objective 1 (***Obj1***) aimed to examine the trade-offs between the time-based attributes of the rail freight service and to provide a transportation solution to the rail sector for improved service levels. For this purpose, a mathematical model was developed and raw data were obtained from various BITRE sources to validate the model within the Australian rail freight network setting. Paper IV (Appendix A-4) provides the detailed model and data analysis.

The aim of Objective 2 (***Obj2***) was to explore the rail sector from a transport geography context. To meet this objective, various sources of secondary data were collected and analysed from both public and private rail and transport related organisations, including rail network information, specific data on freight activity, population distribution and detailed information on the key rail infrastructure. The first piece of analysis was linked to the distribution of demand for rail freight service. As intermodal activity is directly linked to population, a map of Australian population distribution was used and it was integrated with the current intermodal railway network to investigate the geographical proximity of demand with current rail network. Accordingly, this exploration was accompanied with analysing the efficiency of the intermodal terminal system in relation to gauge difference to provide planning recommendations. Paper V provides the details of data collection and analysis (Appendix A-5).

Objective 3 (***Obj3***) focused on the role of intermodal terminals in relation to rail freight activity. To fulfil this objective, secondary data on the Australian intermodal terminal system (such as location and capacity) were collected from various sources, including BITRE, Shipping Australia, NTC and other publicly available sources such as the freight operators' websites. In order to meet this objective, departure-destination data was collected all intermodal terminals in Australia. According to their nature of activity the facilities were categories as intrastate, interstate and port-based terminals. Accordingly, data on freight volumes (containers) were collected for each category. In the next stage, the share of rail was calculated for each category according to their connectivity with the broader transport network. Consequently, descriptive data analysis was conducted to interpret the information and to create specific freight transport implications (Paper VI/Appendix A-6). This analysis was mainly focused to identify the markets in which rail is not performing well. Accordingly, transportation and infrastructure planning solutions were provided in relation to managing the intermodal terminal system to enhance the performance of rail in different markets.

Exploring the current and future role of rail within Australian seaports was the fourth objective of this research (***Obj4***). To meet this objective both primary and secondary data were used. The primary data were collected through the survey which was distributed among operations managers of the Australian ports engaged in intermodal activity. Secondary data were obtained from ports' websites, BITRE, Shipping Australia and other relevant sources (see Paper VII/Appendix A-7). The secondary data used to meet this objective was linked to the container activity in the ports, inbound/outbound movement of containers via different transportation modes and recent investment in rail infrastructure within ports. A descriptive analysis of both primary and secondary data was then conducted to (i) investigate the key impediments facing by the Australian rails sector in ports and (ii) to investigate the share of rail within Australian ley ports. Accordingly, important implications were developed for both rail and port sector in Australia to increase the share for rail in the port market. Table 2.10 summarises the research strategy, data source, data analysis, contribution of each publication and the sections where methodologies are explained in papers in this thesis.

Table 2.10 Summary of data analysis for relevant publications

Paper	***Data source***	***Data analysis***	***Methodology explained in paper***	***Contribution***
Paper I	Literature review	SLR	Section 3	*SRQ1*
Paper II	Empirical (questionnaire)	Quantitative	Section 3	*SRQ2*
Paper III	Empirical (questionnaire)	Quantitative	Section 4	*SRQ3*
Paper IV	Secondary data and simulation	Quantitative	Section 4	*Obj1*
Paper V	Secondary data	Qualitative and quantitative	Section 4	*Obj2*
Paper VI	Secondary data	Qualitative and quantitative	Sections 1 and 5	*Obj3*
Paper VII	Empirical and secondary data	Qualitative and quantitative	Section 4	*Obj4*

2.6 RESEARCH QUALITY CONTROLS

An essential part of any research is to verify the quality of the work (Wortman, 1994). Various scholars have proposed different quality evaluation frameworks for quantitative and qualitative research. However, there is an acceptance that validity and reliability are the key aspects of research quality (Roberts et al., 2006; Morse et al., 2008). Validity and reliability can be applied equally to both research types (Healy & Perry, 2000; Winter, 2000; Riege, 2003; Morse et al., 2008). According to Yin (2009), validity in research can be defined as construct validity, internal validity and external validity. The validity in this research is ensured by taking the following approaches.

First, construct validity was considered to establish the correct operational measures for the research concept being studied, including research strategy, data collection and analysis (Yin, 2009). The survey instrument was prepared based on SLR which is more sophisticated compared to the traditional review of literature. The SLR identified impediments from different aspects of the rail sector to ensure the survey is capable of addressing the research objectives. A careful refinement was also made to ensure the inputs to the survey are capable of answering the research questions. In addition, methodological triangulation was used through the utilisation of both quantitative and qualitative data analyses. Therefore, construct validity was addressed.

Internal validity is important to establishing a causal relationship, whereby certain conditions are revealed that lead to other conditions (Yin, 2009; Almotairi, 2012). To ensure internal validity, the following measures were taken. First, various levels of pilot testing were conducted before the distribution of the survey among participants to enhance the content, wording and message of the survey, meaning that the instrument content was validated. Second, the study included inclusive variables to ensure content validity and coverage. Third, each methodological approach used in this thesis follows its preceding step (for example SLR before EFA and EFA before CFA), meaning that an integrated and continuous validation approach was applied.

EFA and CFA are essential to determining and evaluating the underlying constructs for a set of measured variables and/or instrument used in a research process (Williams et al., 2012). Finally, the statistical and mathematical calculations were conducted by sophisticated software tools and methods, such SPSS and AMOS. The use of SPPS and AMOS are recommended in research procedures to evaluate the validity of casual relationships between the dependent and independent variables (Bryman & Bell, 2011).

External validity is used to determine whether the study's theoretical approach and findings are generalisable beyond the specific context of the study (Yin, 2009; Bryman & Bell, 2011). The theoretical framework of this research was constructed based on well-known management, marketing and multi-modal transportation research, including systems theory, the competitiveness concept and transport service competitiveness. In addition, the appended publications were all published in highly respected journals, including a peer-reviewed conference paper in the field of logistics and transportation. The theoretical approaches developed in this thesis are also applicable to being used in freight transport research with similar contexts, implying that replication logic is possible (Rowley, 2002). Therefore, external validity of the theoretical approach was addressed in this research.

According to Miles and Huberman (1994), the reliability of research is determined by the extent to which the process of the study is consistent and reasonably stable over time and across researchers and methods. To ensure the reliability of this thesis, all procedures regarding data collection and analysis were pre-tested and documented. As the result of consistent data collection and analysis, the methodological tools used in this research will yield stable results when repeated over time. Furthermore, the use of SLR and refinement process ensured reliability of the quantitative methodology by confirming that no point was missing when developing the instrument (Kitchenham et al., 2009).

The reliability of statistical tests was also ensured by utilisation of relevant measurements. Cronbach's alpha was used for assessing the internal consistency of the survey. According to Santos (1999), Cronbach's alpha should be higher than 0.7 for internal consistency. The values of Cronbach's alpha were 0.848, 0.846, 0.819 and 0.713 in this thesis. The Kaiser-Meyer-Olkin (KMO) test was used to measure the sample adequacy which was 0.840, significant at 1 per cent significance level (*p*-value = 0.000). Similarly, Bartlett's test of sphericity was 632.7, significant at 1 per cent. The root mean square error of approximation (RMSEA) test was applied for the CFA stage to ensure reliability of testing. According to Kenny and McCoach (2003), RMSEA must be less than 0.5 for reliability. All the values in the final model fit were significant at 1 per cent and the value for RMSEA was 0.000. Paper II and Paper III in Appendix E and Appendix F respectively provide a detailed presentation of the statistical analysis.

CHAPTER 3: SUMMARY OF PUBLICATIONS

3.1 INTRODUCTION

As this thesis is publication-based, this chapter presents the seven publications associated with this thesis. Importantly, it explains the key findings of each publication and the inter-relationships between the publications and how they individually and collectively contribute to addressing the research question and thus the thesis.

3.2 RESEARCH INTEGRATION AND DEVELOPMENT

The aim of this thesis is to recommend strategies for the Australian rail sector to enhance its competitive position in the non-bulk freight market. To achieve this objective, the impediments to the competitiveness of this important economic sector were identified. Therefore, the starting point of this research was to build a conceptual framework on which the research strategy could be built to answer research questions and meet the objectives. Accordingly, Paper I was developed to build a comprehensive picture of all the impeding factors reported in the literature. Based on the findings of the literature review (Paper I) and the theoretical framework, the context for the empirical part of this thesis was established. Accordingly, the rationale for all the subsequent papers were developed (Papers II to VII).

Thus, Paper II empirically investigated the impact of the impediments on rail's competitiveness from the view of stakeholders. Using the outputs of Paper I and Paper II, Paper III was developed to establish an understanding of the impeding factors from the context of the freight transport market. Paper III investigated the impact of impediments on the key freight service attributes.

This thesis progressed in discrete stages and involved a sequence of related components over time. As a natural consequence of undertaking research in social science, several under-researched areas were identified after undertaking the empirical examination. These areas were identified mainly as the result of quantitative data analysis and interpreting the responses of participants to the open-ended questions.

To investigate these areas, four objectives were developed to cover the under-researched areas. These areas included (i) improvement of the quality of the rail freight service, (ii) studying the rail sector from a transport geography viewpoint, (iii) the role of intermodal terminals in the development of the rail market and (vi) the role of rail in the port-based container flows. These key areas were translated to four research objectives of this research which were essential to meet the primary research question (discussed in section 1.4). The detailed development of research objectives and the need to further investigate the associated areas are discussed in the relevant publications (see Papers IV to VII).

Paper IV which was linked to ***Obj1*** explored the strategies to improve the time-based attributes of rail service using a mathematical model. Paper V (linked to ***Obj2***) investigated the Australian rail sector from a transport geography perspective, including the relationship between population distribution and freight demand, location of intermodal terminals and development of below rail infrastructure over time. Paper VI focused on the role of intermodal terminals in development of playing field for rail in the non-bulk freight market with the aim to meet ***Obj3***. Finally, Paper VII focuses on the role of rail in the port-based market, which is an important market for rail to achieve greater share. Paper VII was linked to ***Obj4***. Figure 3.1 illustrates how the research in total is integrated, the major areas of focus, and their contribution to the research questions and objectives.

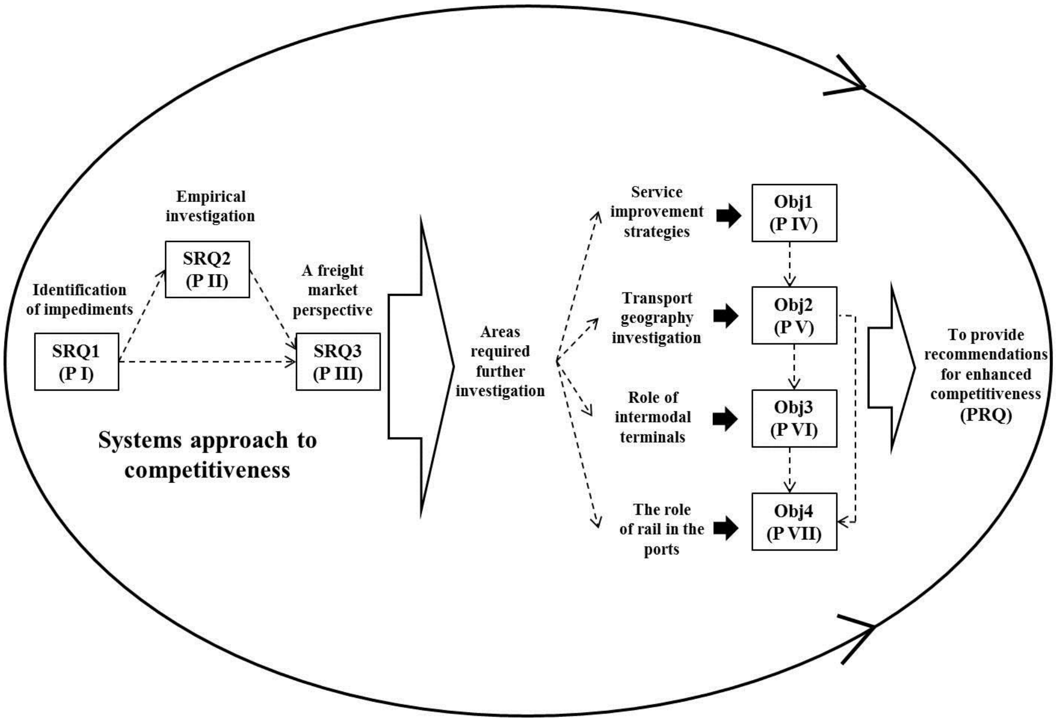

Figure 3.1 Research integration

As discussed before, this thesis has been developed in discrete stages over time to better explore different dimensions of the research problem. Therefore, the results of this thesis were achieved in a sequential style. In other words, every research question and objective provided directions for the sequencing stage, resulting in a profound exploration of the research problem. Table 3.1 shows the prerequisite research behind the development of each publication and their particular contribution to the overall development of this thesis.

Table 3.1 Research flow and inter-relationships between publications

Publication	***Prerequisite***	***Contribution***	***Research area***
Paper I	Available literature on the Australian rail sector and research problem	SRQ1	Identification of impeding factors and the key areas of the study
Paper II	Available literature on the Australian rail sector and Paper I	SRQ2	Empirical investigation of impediments from the view of the key stakeholders
Paper III	Literature on competitiveness in freight transport, Paper I and Paper II	SRQ3	Empirical investigation from a freight market perspective
Paper IV	Paper I, Paper II and Paper III	Obj1	Providing transport solution for service improvement
Paper V	Paper I, Paper II, Paper III and Paper IV	Obj2	A transport geography analysis on the non-bulk rail freight sector
Paper VI	Paper I, Paper II, Paper III, and Paper V	Obj3	Role of intermodal terminals in the development of the non-bulk rail freight market
Paper VII	Paper I, Paper II, Paper III, Paper V, Paper VI and relevant literature	Obj4	Investigation on the role of rail in the ports

3.3 OVERVIEW OF THE PUBLICATIONS

This section presents an overview of each publication by focusing on the purpose and findings. Additionally, this section aims to summarise the contribution of each publication towards an orchestrated organisation.

3.3.1 Paper I - Published

Identification of the impediments to the competitiveness of the Australia rail sector

Ghaderi, H., Fei, J. and Cahoon, S. (2015) ‘The impediments to the competitiveness of the rail industry in Australia: the case of the non-bulk freight market’, *Asia Pacific Journal of Marketing and Logistics*, Vol. 27, No. 1, pp. 127-145.

3.3.1.1 Purpose

The development of this paper evolved from the challenges arising from diverse views in the literature on impediments which have led to a fragmented and biased freight policy-making direction. This paper is linked to ***SRQ1*** which sought to identify the impediments against the competitiveness of the rail sector as reported in the literature. In other words, this paper was developed to establish a focus and summarised picture of all reported impediments that the rail industry is facing by systematically reviewing the reports and studies generated by various stakeholders over the last ten years.

3.1.1.2 Findings

For the first time in the Australian context, this paper identified and reported the impediments to the competitiveness of the rail industry in the non-bulk freight market by systematically reviewing the reports generated by different stakeholders in the last ten years. Using a meta-analysis model, 43 impediments were identified in the areas of policy making, infrastructure and operational aspects. The identified impediments were then applied into a heuristic model to identify the common themes. Four major impeding areas were identified, each of which presents the rail sector with challenges in the non-bulk freight market, including:

- Infrastructural inefficiencies and the need for further integration;
- Governance and inconsistent transport policy;
- Growth and modal shift; and
- Environmental concerns and internalisation of externalities.

“Infrastructural inefficiencies and the need for further integration” was ranked as the main rail industry challenge, while “environmental concerns and the associated costs of externalities” was ranked the least. The results of this paper were used to develop the input for the quantitative approach of this thesis and consequently Paper II and Paper III. Furthermore, this paper introduced areas requiring further research which were reflected in the research objectives.

3.3.2 Paper II - Submitted

Evaluation of impediments from the view of key stakeholders

Ghaderi, H., Cahoon, S. and Nguyen, H-O. (20xx) ‘Evaluation of impediments to the competitiveness of rail sector in Australia’, Submitted to *Research in Transportation Economics*.

3.3.2.1 Purpose

Despite many studies undertaken by various government statutory bodies, there is little understanding of the key impediments against rail’s competitiveness in Australia from the view of stakeholders. Thus, empirical research on this topic remains limited and demands further analysis. Furthermore, stakeholders’ involvement in these studies is fractional and rail has not been studied by its different sectors in Australia (bulk and non-bulk). Given the particular economic and social importance of the non-bulk rail freight sector, dedicated investigation was required. This research therefore, aimed to fill the empirical research gap in the Australian rail sector by systematically identifying the key stakeholders and evaluating their view using sophisticated analytical methods. Therefore, this paper answers ***SRQ2*** and was developed from Paper I to empirically evaluate the impeding factors.

3.3.2.2 Findings

This paper aimed to empirically examine the key challenges facing by the Australian rail sector which has resulted in a broader approach being taken to the notion of rail stakeholders. Through the use of EFA and CFA, this paper recognises that four key impeding areas exist against the competitiveness of the rail sector in Australia, including (i) infrastructure management, (ii) shortage of freight data and poor information sharing, (iii) service delivery and (iv) organisational and commercial interactions. Although similar concerns exist between the empirical findings of this paper and the literature (infrastructure inadequacies, lack of funding and biased access charging systems), there are other impeding areas which were not discussed in the literature, meaning that the available literature does not fully express the industry concerns and challenges. These areas include:

- Shortage of freight data and poor information sharing; and
- Organisational communications and commercial relationships.

This difference however, validates the objective of Paper II to empirically investigate the impediments facing by the rail sector from the view of the key stakeholders. This is an important achievement in recognising and prioritising the industry challenges.

The findings provide important implications for both industry and government in terms of making transport planning and policy decisions to promote the use of rail in the Australian freight markets. This paper also provides important implications on the strategic role of rail towards an integrated national land freight network and enables policy makers to better recognise the poorly performing areas by understanding the impact of recent developments over the last two decades on rail's market share.

3.3.3 Paper III – In press

Investigating the impact of impediments on the key freight service attributes

Ghaderi, H., Cahoon, S. and Nguyen, H-O. (20xx) 'Factors deteriorating competitiveness of the Australian rail sector: a logistical perspective, *International Journal of Logistics Systems and Management*.

Forthcoming

3.3.3.1 Purpose

The aim of this paper is to empirically examine the impact of impediments facing the rail sector in Australia on the key freight service attributes (FSA) from the view of key stakeholders. This paper is linked with ***SRQ3*** which addresses how each FSA are affected by the current impediments. While Paper II developed an overall understanding of the key impeding areas, this paper took one step further by bringing the context of freight transport competitiveness into evaluation of impediments. This approach is beneficial as (i) it identifies the distinct impact of each impediment on the different FSAs and (ii) assists government and industry to make informed transportation and infrastructure planning decision making by identifying the poorly performing areas of the rail sector. The development of this paper evolved from the need to investigate the impediments from a freight transport market perspective and findings of Paper I and Paper II.

3.3.3.2 Findings

Conducting EFA for all the FSAs was useful to (i) reduce the number of factors to the most important from the rail stakeholders' perspective, (ii) identify the unique impediments associated with each FSA, and (iii) to understand what challenges are common among all FSAs. Eight impediments are mutual among the four FSAs (Figure 3.2).

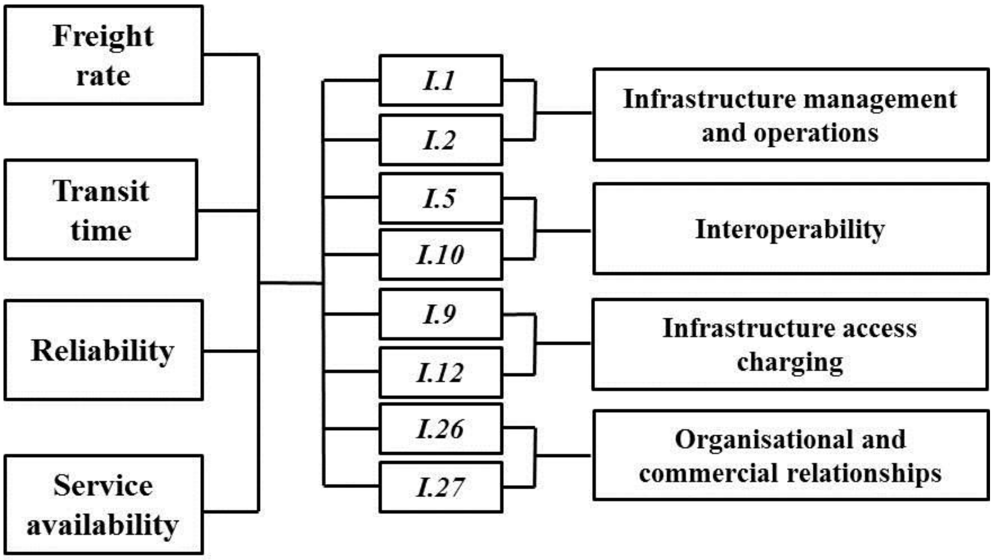

Figure 3.2 Result of four EFAs on FSAs

These impediments are categorised as infrastructure management and operations (*I.1*, *I.2* and *I.10*), interoperability (*I.5*), infrastructure access charging (*I.5* and *I.1*) and organisational and commercial relationships (*I.26* and *I.27*). The appearance of these factors across all FSAs demonstrates their importance, meaning that improving the service levels requires special attention to them. The findings of this paper are more detailed from Paper II as the specific impeding factors associated with each FSA are identified. As different freight customers have different service requirements (for example some are price or time sensitive), this paper provides important recommendations for improvement in each FSA.

3.3.4 Paper IV - Published

Improving service quality by managing the time-based attributes

Ghaderi, H, Namazi-Rad, M. R., Cahoon, S. and Fei, J. (2015) ‘Improving the quality of rail freight services by managing the time-based attributes: the case of non-bulk rail network in Australia’, *World Review on Intermodal Transportation Research*, Vol. 5, No. 3, pp. 203-220.

3.3.4.1 Purpose

Long transit times and low levels of reliability are the key concerns of freight customers hindering their use of rail for their freight movements. This paper quantitatively evaluates the trade-offs between transit time and reliability, which are two influential freight service attributes of transport mode choice. Therefore, this paper addresses ***Obj1*** which provides solutions to improve the quality of rail freight service. A statistical probability function was developed in this paper to calculate the probability of reliability of transport services. Using this function, the impact of changes in the transit time on the probability of punctuality was measured. This method provides the opportunity for rail operators to create a competitive advantage for both internal (terminal and below rail operators for example) and external customers by managing the time-based transport attributes. The development of this paper evolved from the understanding that was achieved from the literature review, Paper II and Paper III on the importance of time-based attributes on the competitiveness of the rail service, and how effective above rail operations contributes to this matter.

3.3.4.2 Findings

The results of the case study in this paper showed that adjusting the transit time can significantly improve the service reliability in different corridors. However, the amount of reliability improvement depends on the corridor length and transit time reduction. In other words, for each departure-destination journey the time reductions must be set in accordance with the reliability improvement targets. Although the results of this research are not empirical in nature, they provide industry managers and academia with a better understanding of the trade-offs between the two time-based attributes of freight service, transit time and reliability. Depending on the operational, marketing or strategic goals, a transport system may aim to enhance the reliability levels by travelling faster which adds extra operational costs or by giving extra slack and maintaining the same operational practice (same speed). This paper suggests that on the North-South corridor (between Brisbane, Sydney and Melbourne) where reliability is a key concern for the use of rail, a reduction in the transit time following the unchanged schedules results in increased cargo availability in the terminal of arrival, and subsequently improved reliability. Accordingly, this will improve the overall competitiveness of rail freight service.

3.3.5 Paper V - Published

A transport geography investigation into the non-bulk freight sector

Ghaderi, H, Cahoon, S. and Nguyen, H-O. (2015) 'An investigation into the non-bulk rail freight transport in Australia', *The Asian Journal of Shipping and Logistics*, Vol. 31, No. 1, pp. 59-83.

3.3.5.1 Purpose

Understanding the movement of freight distribution in transportation science and geographical research is important to make transportation and infrastructure decisions. Therefore, this paper was developed to meet the second research objective (***Obj2***) which is to investigate the rail freight sector from a transport geography perspective. This is an important analysis due to the size of Australia and unique population distribution. To meet this objective, this paper provides an extensive transport geography analysis on how the current network and demand distribution limit the scope for rail transport in Australia. To achieve this objective, this paper investigates the efficiency and operational management issues by focusing on three key transport geography areas: the level of track compatibility and the relevant operational issues, the demographics of non-bulk freight in Australia and the current status of intermodal terminals in relation to rail connectivity and demand. This understanding is essential for the rail sector to make infrastructure planning decisions in the medium and long term. The need for this analysis evolved from the general literature stage and the outcomes of Paper II, Paper III and Paper IV in the areas of service delivery and fixed infrastructure such as intermodal terminals and below rail network.

3.3.5.2 Findings

By analysing the three research themes in the former section, a more detailed understanding of the current inefficiencies and infrastructure shortages facing the non-bulk rail freight sector in Australia was achieved. In relation to the issue of track incompatibility, a significant amount of investment is required for track standardisation to enable rail capture larger market share of freight within regional areas. Track standardisation is a critical issue for freight movements with origins in

Australian States with a different gauge size to the standard interstate tracks. This will add extra transhipment costs to the total door-to-door freight cost, limiting the cost competitiveness of rail in important interstate markets such as QLD-NSW, NSW-VIC, QLD-VIC and VIC-SA. In addition, the extra operational time that containers stay in the yards as well as transhipping them between different trains will increase the transit time. The standardisation of track however, is not a short-term and low cost improvement option due to various reasons, mainly due to the significant associated cost and the complex ownership structure.

This paper also highlights the crucial role of intermodal terminals for the effectiveness of rail in attracting freight and the means to improve the overall service quality, with a special focus on the intermodal terminals serving the key Australian ports. However, detailed investigation of this area was out of the scope of this paper and required further study. Therefore, Paper VI and Paper VII were developed to investigate the role of intermodal terminals in providing a playing field for rail in the different segments of Australian non-bulk freight market. In addition, based on the findings, this paper provides valuable recommendations to the rail sector and government to enhance the competitiveness of rail.

3.3.6 Paper VI - Submitted

The role of intermodal terminals in the development of non-bulk rail freight market in Australia

Ghaderi, H, Cahoon, S. and Nguyen, H-O. (20xx) ‘The role of intermodal terminals in the development of non-bulk rail freight market in Australia’, Submitted to *Case Studies in Transport Policies*.

3.3.6.1 Purpose

This paper develops a more in-depth understanding of the role of intermodal terminals in the development of the non-bulk rail freight market in Australia by using various published and original data sources. This is followed by detailed explanation of the role in the non-bulk freight market as a whole and their contribution in generating freight volumes for rail in different subsystems. The purpose of this paper answers ***Obj3*** and its development evolved from the general findings of Paper II and Paper III and a focused investigation on the intermodal terminals which was demonstrated in Paper V.

3.3.6.2 Findings

This paper found that intermodal terminals play a critical role in the efficient movement of non-bulk freight across Australia. The analysis of collected data shows that a combination of establishing new terminals (especially in the regional markets) and the expansion of certain existing terminals are required to cater for the expected growth in Australia's seaborne and domestic trade. In relation to capacity, sufficient terminal facilities are available in terms of handling and storage yards in all sub-systems for the current volumes. However, this capacity is not efficiently employed as the result of numerous infrastructural and regulatory constraints.

This paper also demonstrates that port-based container flows are potential market segments for rail to achieve greater share. In the port-based sub-system, three elements are essential for a disruption-free movement of freight trains across Australian deep-sea terminals. First, the rail connectivity to the ports is a critical factor. In Sydney and Melbourne, dedicated rail corridors are needed to lessen the interfaces between the freight trains and highly prioritized passenger trains in the shared network. It is expected that rail may become more competitive in the future when increased urban trade and traffic make road transport less flexible and more costly in metropolitan Sydney and Melbourne. Since this is an important market for rail, further research was required to investigate the key impeding areas against efficient operations of rail in the ports. This need resulted in the development of Paper VII.

Finally, Paper VI explains that poor and adversarial relationships between different players across the intermodal terminal system have resulted in low rail productivity. Many container terminals in Australia are unionised, and often there is one union covering a range of employees. This multifarious working environment has resulted in several strikes and stoppages of terminals operations in the last two decades. Therefore, a more collaborative approach needs to be in place to maintain the relationships between the supply chain actors.

3.3.7 Paper VII - Published

The role of rail in the port-based container market

Ghaderi, H, Cahoon, S. and Nguyen, H-O. (2015) 'Impediments to the competitiveness of the rail sector in the Australian port-based container market' *Proceedings of the 2015 International Association of Maritime Economists Conference (IAME)*, Kuala Lumpur, Malaysia.

3.3.7.1 Purpose

The number of containers handled by Australian ports has quadrupled over the past two decades due to significant growth in Australia's international trade and increasing population. Despite the significant growth in port-based container volumes, rail's share in the land-based movement of this traffic is very small, principally due to lower service levels when compared with those offered by the road sector. Therefore, the purpose of this paper addresses ***Obj4***. This paper first establishes a clearer image of the role of rail in the Australian port-based container flows using both published statistics and the authors' original analysis and second, to empirically identify the key impediments to the competitiveness of rail in the port-based market. This paper, developed from the findings of Paper II, Paper III, Paper V and Paper VI, demonstrated the need for detailed investigation on the role of rail in the Australian port-based market and to evaluate the key challenging areas.

3.3.7.2 Findings

Three major findings are evident from the data collection and analysis. Firstly, inadequate infrastructure was found to be a key impediment for the use of rail in Australian ports. This mainly includes intermodal infrastructure, and the shortage of both above and below rail infrastructure. Secondly, poor interoperability and operational practices are crucial elements for seamless rail operations within ports. Thirdly, port managers perceive that effective transport policy is lacking from different levels of government and although a greater role for rail is apparent a single national rail system is first required.

This paper suggests there are opportunities for rail to increase its share, due to an increase in trade and traffic that will make the road transport less flexible and more costly in the urban areas. However, this depends on various enhancement options. The preliminary approach is the enhancement of below rail infrastructure, in particular the establishment of dedicated freight lines to and from ports which is a key catalyser to improve the quality of rail service. Under the current condition where passenger and freight trains are sharing the already congested urban rail infrastructure, a greater rail share does not seem plausible. The general understanding is that there is interest from ports for increased rail activity, mainly due to establishing a greener image. This is particularly true as Melbourne, Sydney, Brisbane and Fremantle are in close proximity to residential areas. However, enhanced rail connectivity cannot be achieved without close collaboration between ports and the governments of the host region, especially in Sydney and Melbourne where there is limited land available to be utilised for railways and terminals.

This paper concludes that port-based container flow is a key market for rail. However, to achieve this, it must be appreciated that impediments exist including infrastructure shortage, commercial barriers and inconsistent standards, all of which may result in rail not being the first choice of freight managers.

3.4 SUMMARY

Although the published papers are separated into discrete topics, its organisation has been orchestrated and integrated to be read as a single rational argument and to meet the relevant research question/objectives. This approach was beneficial to better addressing the primary research question of this thesis by investigating different dimensions of the research problem and to provide explicit recommendations relevant to the nature of challenges facing by the Australian rail sector.

CHAPTER 4: CONCLUSION

4.1 INTRODUCTION

This thesis is an empirical study investigating the Australian rail sector in the non-bulk rail freight sector with the purpose of providing strategies for enhanced competitiveness. The research necessitated a comprehensive analysis of the key impeding factors against the competitiveness of the rail sector in Australia, as well as an extensive review of intermodal freight issues. The thesis adopted a quantitative research methodology to answer the primary research question. The primary research question was broken into three secondary research questions as the empirical examination of thesis. After conducting the empirical examination, four important areas were identified which required further research o better answer the primary research question. The four areas were then translated into four research objectives. The detailed findings of each research question and objective were presented in Chapter three and related publications. This concluding chapter provides a general conclusion to this thesis and discusses the contributions for academia and industry. Finally, the limitations of the thesis and directions for future research are provided.

4.2 SUMMARY OF MAJOR FINDINGS

Rail transport plays a critical role in the Australian economy. In the near future where truck activity will place further pressure on urban networks, it is expected that rail will become an even more attractive transport solution. Enhancing rail productivity will provide strong benefits for the Australian transport sector and society as a whole. The growth in rail's volume is likely and necessary to ensure sustainable economic growth. This is mainly due to the projected freight demand, the necessity to minimise the external costs of freight activity, potential rises in fuel prices and greater attention to impacts on the environment. Fuel cost accounts for the single largest cost item of long-distance road freight operating costs (30 per cent) (BITRE, 2009). Specifically, the future introduction of greenhouse gas emission will be based on fuel charges which will likely increase the freight rate offered by road sector.

Given the importance of the non-bulk freight sector as a key mechanism for rail achieving a greater share of the freight market, this thesis evaluates the importance of existing impediments against the competitiveness of the rail sector from the perspectives of various stakeholders in this particular market. This thesis also sheds light on the strategic role of rail towards an integrated national land freight network and enables policy makers to better recognise areas of weakness. Additionally, this research is the first national study aiming to fill the empirical research gap in the Australian rail industry by systematically identifying the key stakeholders and evaluating their view using sophisticated analytical methods.

From the findings of this thesis, it is evident there are a number of impeding areas impacting on the competitiveness, performance and commercial viability of the Australian rail sector, particularly in the non-bulk freight market. For many years the Australian rail sector has been in a downhill cycle of low investment, reduced market share and subsequent difficulties to justify infrastructure investment. Despite a number of attempts and developments over the past three decades made by different levels of government and industry to bring about change, there is still much to be achieved to enhance the attractiveness of rail as an efficient and more environmentally friendly mode of transportation in the Australian non-bulk freight market. However, as this thesis highlights, changes are required in terms of infrastructure, operational practices, working culture, regulations and policy to bring productivity into the rail sector.

The empirical findings of this thesis reveal that in addition to the physical barriers existing in the rail infrastructure, there are major market and economic distortions preventing the rail sector from improving its productivity. As highlighted in previous chapters and published paper, these are mainly categorised as (i) a lack of consensus between different levels of governments when making transport policy, and (ii) a lack of a level competition playing field.

In relation to the lack of consensus, the findings of this thesis highlights that absence of an integrated long term transport policy framework is a key area reducing productivity of the rail sector. For example, there is a fragmentation of roles within government where infrastructure initiatives require the involvement of different levels of government. This in turn results in reduced input from different parties when developing transport policy. Developing a comprehensive and integrated framework for transport policy is consequently challenging due to this fragmentation, overlapping and multiple interfaces between levels of government involved in transport and infrastructure planning. Solving this issue requires greater leadership at the national level to create transparency and consensus across different tiers of government.

In addition, there is sometimes misunderstanding of the role of government as policy maker, regulator or operator. Therefore, it is not clear where the responsibility resides for developing the policy, approval process, asset ownership and management. As the result of this confusion, cost-shifting occurs between different tiers of government resulting in rail infrastructure projects being considered as individual programs rather than seeing their contribution to the objectives of creating an integrated national land freight system such as those developed in AusLink. Moreover, arrangements between different levels of government, departments and relevant jurisdictions do not often exist prior to funding or planning decisions. For example, decisions related to establishment of intermodal terminals are not widely discussed with the rail operators and the wider logistics industry.

Regarding the competitive neutrality, two issues exist as (i) biased funding and (ii) pricing approaches. Unlike the road sector, the private sector contributes largely to rail infrastructure investment, both in above and below rail operations. From a public investment perspective, traditionally, there has been an underinvestment in rail infrastructure from Commonwealth infrastructure related funding; since the road funding role was expanded in the 1970s. As a result of inadequate rail infrastructure, rail's transit time and reliability which are the key determinants of market share, have considerably suffered. The second element of the competitive neutrality is linked to the current pricing regimes in place. Pricing systems across modes must consider the full economic and social costs of each transport mode to gain the maximum benefits (reduced freight rate and environmental costs for example) from their combination. From the infrastructure access pricing perspective, the current heavy vehicle pricing system does not embrace the actual costs of maintaining and upgrading the network. This thesis highlights that biased infrastructure access pricing systems are not only a key challenge for the rail sector to achieve a greater share (especially on the shorter corridors), but also it is a serious concern for the wider community of Australia who are indirectly paying the cost and impact of heavy vehicles on the infrastructure.

The provision of road infrastructure, especially in the urban areas, is constrained by the limited land availability. This has led to the development of expensive infrastructure, such as tunnels and bridges, which are not commercially viable. Under the current road pricing system, road vehicles are charged for the use of arterial and local roads via a nationally used system, which does not capture the full cost that heavy vehicles impose on the road network, meaning that the remaining cost is shared equally between all users, including private travellers. Although the financial cost and benefits of a freight transport mode are of particular importance, transport policies must be developed in such way to capture the non-financial aspects associated with freight activity. The current pricing system fails to internalise the social and environmental costs of transport modes.

The empirical findings of this thesis reveal that poor internalisation of freight costs is a major challenge for the rail sector. The external costs of freight activity, such as congestion, accidents and environmental degradation, has not been accounted in the freight rates and has been transferred to society. As such, these impediments are resulting in distorted transport decisions from the freight industry and in turn will not ensure a safe, sustainable and efficient freight transport system for Australia. A balanced competitive playing field will ensure the industry chooses the most efficient combination of transport modes. This approach will lead to greater utilisation of assets and lesser cost being imposed to the society.

In conclusion, in order to improve rail's productivity, a more mature and collaborative approach is required among all the actors to establish win-win solutions and considering the non-bulk freight task in a more integrated approach rather than providing road or rail scenarios. This in turn will bring long-term and sustainable benefits to the Australian economy as a whole.

4.3 RESEARCH CONTRIBUTIONS

This thesis makes several contributions to the industry and academia. The contributions are presented through two areas. First, those related to the contextual and industry-related focus of this research and the second area is linked to the methodological, theoretical and academic aspects of this research.

4.3.1 Contextual and industry-related contributions

Firstly, this study provides a more transparent image of the key challenges faced by the rail sector in Australia. These challenges were previously ambiguous, mainly due to the lack of empirical research and little stakeholder involvement. This research therefore, provides a detailed and rigorous understanding of these challenges in a national context. Although many of industry challenges were previously identified, this thesis follows an evidence-based approach with the use of scientific methods to integrate research in the Australian rail sector. Accordingly, a more convincing and feasible framework was developed to provide strategies for the rail sector to enhance competitiveness.

Secondly, this thesis provides important recommendations for the Australian rail sector and government to make informed transportation and policy decisions, including those related to below rail infrastructure, intermodal terminals, access pricing, funding and the cultural changes required to improve productivity of the entire system. This was achieved by establishing a better understanding of the rail sector under a systems setting, that empirically evaluated the industry challenges and integrated those challenges in a national context with successful policy and practice applied internationally.

Thirdly, this research contributes to the area of port hinterland development by highlighting the important role of rail in port-based container flows. As the result of increased road congestion in port hinterland and intensified attention to environmental impacts of port activity, many governments aim to promote the use of rail. The empirical results of this research from the Australian context identifies and discusses the challenges in relation to this strategic shift and provides important recommendation to government and industry to facilitate a greater role for rail in port-based flows.

Finally, this thesis identifies various organisational and operational areas that have been continuing to create conflicts between different tiers of governments and freight industry in undertaking the freight task. Over the past these conflicts have been resulting in significant work stoppages such as 1998 Australian Waterfront Dispute. Throughout this thesis various recommendations have been provided to avoid these clashes in future. This study suggests that dedicated research is required to exclusively focus on the roots of conflicts from policy and operational perspectives.

4.3.2 Methodological, theoretical and academic contributions

Firstly, this thesis contributes to the stakeholder management and rail transportation literature by developing the concept of rail stakeholders. This concept is important as it guides empirical rail transport research in future where participation of stakeholders is required. Furthermore, as the rail freight transportation is an emerging area, the concept of rail stakeholders developed in this thesis will assist future studies to better explore the rail freight sector and the roles of different stakeholders.

Secondly, this study contributes to transportation research and business management studies, especially to rail transportation literature. Since intermodal rail transportation and policy are emerging topics in intermodal transportation research, this thesis assists not only in understanding the factors for the development of intermodal freight markets and to increase the share of rail, but also in understanding the factors influencing the competitiveness of rail transport in intermodal markets.

Thirdly, this study contributes to the rail transport research by investigating the infrastructural and demand aspects of rail transportation and management. This is important achievement as it helps researcher to identify the key factors influencing the management of intermodal rail transport. By conducting EFA and CFA and then detailed logistical analysis of results, this study demonstrate there is a symbiotic relationship between the quality of infrastructure and operational performance. This is an important contribution as it provides important insights for policy makers and industry to understand the situations where the solution lies in infrastructure development/upgrade or greater market activity is required.

Fourthly, and most importantly, this thesis contributes to the concept of competitiveness and systems management by developing a conceptual framework which integrates the systems approach with the competitiveness concept. As many organisations aim to gain more control over their activities by structuring their boundaries, this theoretical framework will assist researcher to place different divisions of an organisations into system elements and link those elements to competitiveness attributes. In other words, this approach is beneficial to evaluate the competitiveness of an industrial sector by identifying its particular components (inputs, processes and outputs) and investigating how these components influence the competitiveness.

Fifthly, this research is the first to identify and explain the relationship between infrastructure provision and freight activity. This was achieved by investigating the development model of intermodal terminal infrastructure and its sub- in relation to rail freight activity. The analysis of this symbiosis nexus revealed that in some freight markets greater infrastructure results in additional freight activity, where in others it is the additional freight activity or demand that justifies the investment and accordingly infrastructure provision. This conceptual approach is a unique contribution to the infrastructure research to develop effective infrastructure planning and policies in relation to the relevant market conditions.

Finally, this research contributes to the methodological development of intermodal transportation research in the following two ways. Firstly, a systematic literature review was adopted in this thesis to identify the key impediments against the competitiveness of the Australian rail sector. The use of this type of literature review in social science research has been increasing over the last two decades (Thomas et al., 2004; Afzal et al., 2009). However, this methodology has not received enough attention in transportation studies and there is no clear indication of the use of this approach. Systematic reviews follow a well-defined methodology that reduces bias in data collection. It also provides a comprehensive analysis of the literature that conventional literature reviews are unable to attain. The use of systematic reviews in business management research keeps the researcher on track, but also enhances the reliability of the literature review findings. More importantly, traditional literature reviews are restricted to literature already known to the researcher, or literature that is found by conducting little more than cursory searchers, meaning that the same studies are frequently cited which introduces a persistent bias in literature reviews (Mallett et al., 2012). However, systematic reviews reduce the bias by applying predefined data collections strategies, inclusion and exclusion criteria and meta-analysis. Particularly in transportations studies, researchers can benefit from this advantage by identifying the trending topics and exploring the gaps of research. Additionally, the data analysis can be designed in a way to help achieve the research objectives.

Secondly, one of the key concerns when conducting social science research is receiving a low response rate that is often associated with studies using surveys as a method of data collection. Quite recently, the use of social media such as Facebook, and Twitter is increasing among the various population cohorts who constitute the target of academic research (McCorkindale & DiStaso, 2014). At the professional and industry level, people are increasingly using social media such as LinkedIn to liaise with one another and share vital business connections in their respective industries. This offers a sublime window of opportunity for researchers to reach the target population under investigation. Likewise, LinkedIn was used in this research to identify, filter and contact the respondents. As finding individuals' contact information was not easy to achieve, this approach was beneficial to develop an accurate sample and increase the response rate. The approach used in this thesis highlights the potential benefits of social media in reaching obscure populations such as rail stakeholders. Furthermore, the high response rate (42.2 per cent) achieved demonstrates that social media is not only capable of helping researchers to increase response rate, but naturally offers a unique opportunity to collect high quality information from a network of senior industry professionals who are not easily reachable. Therefore, the data collection strategy adopted in this thesis contributes to the domain of data collection in social science, particularly in the field of business management.

4.4 RESEARCH LIMITATIONS

Limitations are an inevitable aspect of all research. Likewise, this research has limitations associated with the research strategy. Firstly, in this research a web-based questionnaire was used to collect the data required to answer the research questions. Therefore, this approach may have had limitations in terms of coverage, software reliability and uncertainty about the respondents (Sue & Ritter, 2007; Sakalayen, 2014). However, given the vast distribution of the target population, time frame and limited resources, this approach was critical to bring the Australian rail stakeholders. To mitigate the limitations of web-based survey, the survey was carefully designed and presented for ease of use by respondents. Also the sampling frame was developed to avoid bias and finally, the innovative use of social media was critical to contact participants and achieve a high response rate.

Secondly, the length of an online survey may have had limitations where some respondents skipped the part of questionnaire related to the impact of impediments on the FSAs, resulting in a small difference in the size of samples associated with RQ2 and RQ3. To avoid incomplete responses, two pathways were established for the respondents to skip the sections in which they didn't have sufficient knowledge. Moreover, as the research questions were not interrelated, both samples were sufficient to conduct the relevant analysis and this difference did not have any adverse impact on the overall research quality and meeting the pre-defined objectives.

Fourthly, this thesis follows a cross-sectional approach, implying that the study was conducted in a specific point of time. Accordingly, situation may provide different outcomes in a different time-frame. For example, the market conditions, regulation and infrastructure quality might be different in a different time and this will provide different results.

Fifthly, when meeting *Obj1* (to mathematically examine how the time-based attributes of the rail freight service quality can be improved) limited secondary data on rail freight was considered as an issue to develop the mathematical model. The available data was based on the total travelling time. Terminal operations time was not collected separately. Therefore, the developed mathematical model was restricted to provide improvement strategies on the total travelling time scenario.

Sixthly, there are limitation in regards to availability of data when meeting *Obj2*, *Obj3* and *Obj4*. Paper V which deals with exploring the rail freight sector from a transport geography perspective (*Obj2*) employs several secondary data. This investigation employs population distribution as the indicator for non-bulk rail freight demand. Although population is a major determinant of intermodal activity, in some cases it may provide biased interpretation. This decision was made to due unavailability of data on other key sources of demand. The collected data for Papers VI which deals with *Obj3* also suffered from data availability for Flinders Ports (South Australia) and a missing year of rail-related data for Port of Melbourne. This in turn slightly weakened the descriptive analysis. In relation to Paper VII (*Obj4*), the number of ports engaged with intermodal activity in Australia was limited to 13. Although a high response rate was received from the port mangers, the analysis in this paper was limited to descriptive interpretation of data.

Finally, this thesis has limitation in terms of generalisability. The theoretical framework of this thesis can be applied to any freight market where competition exists between different transport modes. However, the specific strategies developed in this research in terms of transportation management, infrastructure planning and policy were made according to the specific market condition, infrastructure quality and regulation that exist in Australia.

4.5 DIRECTIONS FOR FUTURE RESEARCH

This research provides several directions for future research. Firstly, this thesis investigated the view of rail freight sector on the key challenges of various service quality attributes. As a future research agenda, the importance of service attributes from the shippers' and freight forwarders' perspectives can be empirically studied to be integrated with the outcomes of this thesis to provide important implications in different ways. This approach will provide valuable information for the rail sector to target the poorly performing attributes which demand higher service levels from the freight customers. Moreover, it will reveal potential misunderstandings between the rail sector and transport market when creating transportation solutions. Finally, this integration is important as it creates consensus across the supply chain actors when making infrastructure planning and policy decisions. Additionally, as different freight corridors have different requirements from the customers, this approach can be conducted for different origin-destination routes where there is a potential market for rail.

Secondly, as the key Australian ports are undergoing significant privatisation reform, greater commercialisation might bring productivity to the port sector. In contrast, by transferring monopoly assets to a private entity this approach could eliminate the government funding on port-related rail infrastructure and establish a monopoly environment for the new operator. Hence, this thesis suggests it is critical to investigate the broader benefits and drawbacks of port privatisation on the future role of rail in the Australian port-based container flow.

Thirdly, the role of efficient below rail infrastructure for service quality and enhanced competitiveness was reviewed from a transportation management perspective in this research. Track incompatibility in Australia is a significant impediment to asset mobility, cost reduction and network integration. Future research could be conducted to economically evaluate the cost and benefits of track standardisation on the quality of rail freight service in Australia. This in turn will provide important information to the government, freight industry and rail sector in particular to make infrastructure (above and below rail) planning decisions. Moreover, within this context, future research must be conducted to explore the potential markets in which track compatibility will boost the demand for rail transport.

Fourthly, subject to data availability on terminal operation times, this research recommends that future optimisation research should be conducted to assess the impacts of reducing terminal operations time on the total service time for the key origin-destination routes. This will provide important recommendations for the rail operators to improve the time-based attributes of the rails service by managing the terminal operations.

Fifthly, this study suggest that research must be undertaken to exclusively compare the effectiveness of transport policies for promotion of rail in Europe and North America with those currently in place and development in Australia. This will provide various learning opportunities for government and industry in Australia to make effective decisions in relation to infrastructure planning, investment and pricing.

Finally, considering the future growth in the Australian freight activity, denser urban areas and rises in fuel price, this thesis will increase the research emphasis and interest on rail by highlighting its broader benefits to the community and industry, including reduced cost of externalities, improved land use, lowered transport cost and decreased congestion. As is apparent from international (mainly Europe and North America), greater use of rail is necessary for Australia to meet the future challenges.

APPENDICES

Appendix A-1 has been removed for copyright or proprietary reasons.

Ghaderi, H., Fei, J., Cahoon, S., (2015), The impediments to the competitiveness of the rail industry in Australia: the case of the non-bulk freight market, Asia Pacific journal of marketing & logistics, 27(1), 127-145.

APPENDIX A-2 – Paper II

Evaluation of impediments to the competitiveness of the rail sector in Australia: Empirical research and evidence

Hadi Ghaderi, Stephen Cahoon and Hong-Oanh Nguyen
hghaderi@amc.edu.au
Department of Maritime and Logistics Management, National Centre for Ports and Shipping
Australian Maritime College, University of Tasmania, Launceston, TAS 7250, Australia

ABSTRACT

The introduction of AusLink Green Papers in 2002 and 2004, towards the National Land Transport Plan and Funding Framework were clear steps to develop a national freight system in Australia. Despite these efforts, the development of an integrated freight system has failed to eventuate because of a number of impediments. This has left the rail sector in a sub-optimal state, resulting in a shrinking market share and consequent difficulties in economically justifying any investment. Given the importance of the non-bulk freight, this paper evaluates the existing impediments against the competitiveness of the rail sector from the perspectives of various stakeholders. This paper has adopted an empirical approach to examine the Australian rail sector which has resulted in a broader approach being taken to the notion of rail stakeholders. Through the use of EFA and CFA, this paper found four factors that are impeding rail development, these being infrastructure management, shortage of freight data and poor information sharing, service delivery, and organisational and commercial interactions. The findings provide important implications for both industry and government in terms of making transport planning and policy decisions, but also useful insights by identifying the weak parts of the rail sector and directions to target them.

1. Introduction

Australia is facing major challenges in undertaking its freight task. Over the next few decades the land freight activity will grow substantially with the population growth patterns continuing to have lesser penetration into regional areas. Congestion on urban networks is already restricting the mobility of freight and people, costing the economy billions of dollars annually (Meng et al., 2013). The delays caused by such congestion not only have an impact on transport users and operators, they will also significantly impede Australia's international competitiveness by forcing prices to increase.

The introduction of AusLink Green Papers in 2002 and 2004, for example, towards the National Land Transport Plan and funding framework of the integrated land infrastructure network were clear steps taken by the Commonwealth Government to recognising the challenges confronting a viable national freight system. This progress was an approach consistent with the deregulation of rail and the establishment of the Australian Rail Track Corporation (ARTC) as the single manager of interstate rail networks by the Commonwealth Government in 1997 and the establishment of the National Transport Commission (NTC) in 2003. Since then, various levels of government have emphasised the promotion of greater interoperability to reap benefits from collective competencies.

However, despite these efforts, the development of an integrated freight system has failed to eventuate because of a number of impediments. These include physical barriers such as the shortage of rail infrastructure, and other institutional impediments such as discriminatory pricing and financing mechanisms that favour the road sector. This legacy has left the rail sector in a sub-optimal state, resulting in a shrinking market share and consequent difficulties in economically justifying any investment (Spriggs and von der Heidt, 2014, Ghaderi et al., 2015c). Given the importance of the non-bulk freight sector as a key mechanism for rail achieving a greater share of the freight market (Woodburn, 2012), this paper evaluates the importance of existing impediments against the competitiveness of the rail sector from the perspectives of various stakeholders in this particular market. This paper also sheds light on the strategic role of rail towards an integrated national land freight network and enables policy makers to better recognise areas of weakness.

The organisation of this paper is as follows. The next section provides a brief background to the recent significant events of the Australian rail sector, followed by the methodology and data collection procedures. An analysis of the survey results is then presented, followed by a discussion. Finally, conclusions are discussed, including policy implications for the rail sector.

2. A brief review of recent rail policy developments in Australia

The Australian freight industry has been subject to microeconomic reforms over the last three decades. Associated with these developments, the rail sector has undergone significant physical and legislative developments (Everett, 2005). This section discusses the recent key developments towards creating a national integrated freight network and framework for rail privatisation with the creation of the first national entity for managing rail infrastructure.

To enhance the use and management of national rail infrastructure, the Commonwealth, State and Territory Governments agreed in July 1991 that a company should be established to take over operations of interstate rail services from State governments (Australian Government, 1991). This agreement led to the establishment of the National Rail Corporation (NRC). As a result of the microeconomic reform packages in the 1990s, it became increasingly evident that the limited purview of the existing Federal competition policy schemes would profoundly constrain the scope for further economic reforms and the development of a competitive economy in Australia (Kain et al., 2001). This inquiry led to the development of the Hilmer Report (Hilmer, 1993) on National Competition Policy.

Following the introduction of the Hilmer Report and the development of the National Access Regime for access provision to nationally significant infrastructure under Part IIIA of the

Trade Practices Act, the deregulation of rail in Australia actually commenced by vertically separating the below-rail and above-rail components.

NRC then began implementing third-party access to the freight operations of the interstate track in 1993. Two years later, in July 1995, the first private train service on the national network was commenced by SCT Logistics between Perth and Melbourne. Over that period, the implementation of the Hilmer recommendations introduced competition in the rail market and effectively abolished State government monopolies (Everett, 2006), but failed to bring productivity and competitiveness into the rail sector resulting in rail's share continuing to decline during this period.

In November 1996, the Australian Government introduced a major reform package that included the sale of the Australian National Railways Commission[1] (AN) and NRC, and establishment of ARTC. The objective of these reforms was to respond to rail's shrinking market share by increasing private sector involvement, lowering the cost of freight transport, meeting the changing needs of the transport industry and generating long-term employment in the rail sector. ARTC was created to form a one-stop-shop for rail operators seeking access to the national interstate rail network. In February 1998 it was incorporated under Corporations Law and commenced operations in July of that year. Currently ARTC has responsibility for the management of over 8,500 route kilometres of interstate standard gauge track (ARTC website, 2012). It owns the interstate track from South Australia to Kalgoorlie in Western Australia and to Broken Hill in New South Wales (NSW), with rights to sell access on the extension to Perth which is managed by Brookfield Rail. ARTC also has a lease on the interstate track in Victoria and NSW (Figure 1).

[1] In July 1975, Australian National Railways was formed to take over the operations of the federal government owned Commonwealth Railways.

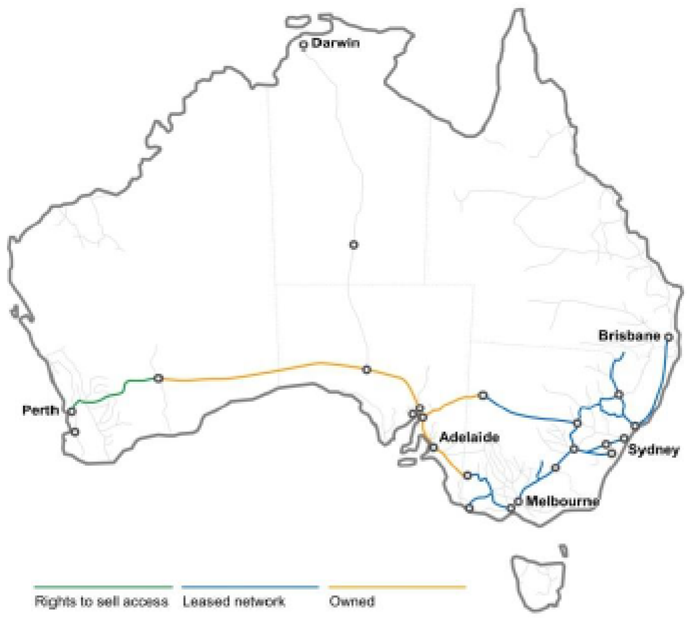

Figure 1 Interstate track managed by ARTC
Source: ARTC Website

Permission to access tracks in other states must be sought from the relevant access provider body. Rail access arrangements under the National Access Regime provide the industry and train operators with a legal right to negotiate the price, backed up by arbitration from the Australian Competition and Consumer Commission (ACCC) should commercial negotiations prove unsuccessful (ARTC, 2008). This approach has become a key catalyst for boosting competition in the interstate rail sector and has improved economic efficiency for both above-rail and below-rail operators through better utilisation of available infrastructure (Infrastructure Australia, 2013). ARTC has kept access prices down to assist the rail industry in gaining market share (Port Jackson partners, 2005). However, current charges may not sustain the infrastructure costs in the long run, and hinder new investment from commercial operators in the rail sector.

Since the establishment of ARTC, there have been major enhancements to both below-rail and above-rail segments from different tiers of government and the private sector, such as the opening of the central corridor between Alice Springs and Darwin (2004) and the extension of the double-stacking network in 2008 following ARTC track enhancements. In only five years, between 2009 and 2014, ARTC has invested over three billion dollars on a range of track improvements in the north-south corridor (between Melbourne, Sydney and Brisbane) where the main non-bulk freight volumes are carried (ARTC, 2014). These efforts have resulted in several benefits to the operators and end users, including lowered freight cost, improved reliability levels and reduced transit times. Despite the recent developments in the rail sector, the objectives of implementing a national land freight network has failed to eventuate as achievement of this goal necessitates an integrated rail system which does not appear plausible in the near future due to both physical and legislative obstacles.

Although the post-Hilmer developments resulted in a greater involvement of the private sector in rail operations, its failure in bringing integration to the national freight system is evident. The recent developments were principally made to meet the social and economic interests of individual States rather than considering Australia as a single nation facing significant challenges in undertaking its freight task. In the other words, deregulation of rail and attempts to create a national interstate rail network has delivered a system comprised of discrete State government entities with different access regimes in different sub-markets, different pricing and funding policies, and different regulatory mechanisms (Everett, 2006), which itself is the source of ongoing disputes and conflicts between various stakeholders (Bordignon and Littlechild, 2012). Figure 2 provides a year-based summary of rail's share in the non-bulk freight market along with the relevant key industry events at that time.[2]

[2] Note that road and rail are the key players in the non-bulk freight market in Australia. The aggregated share of sea and air freight was only around 4 percent in 2014.

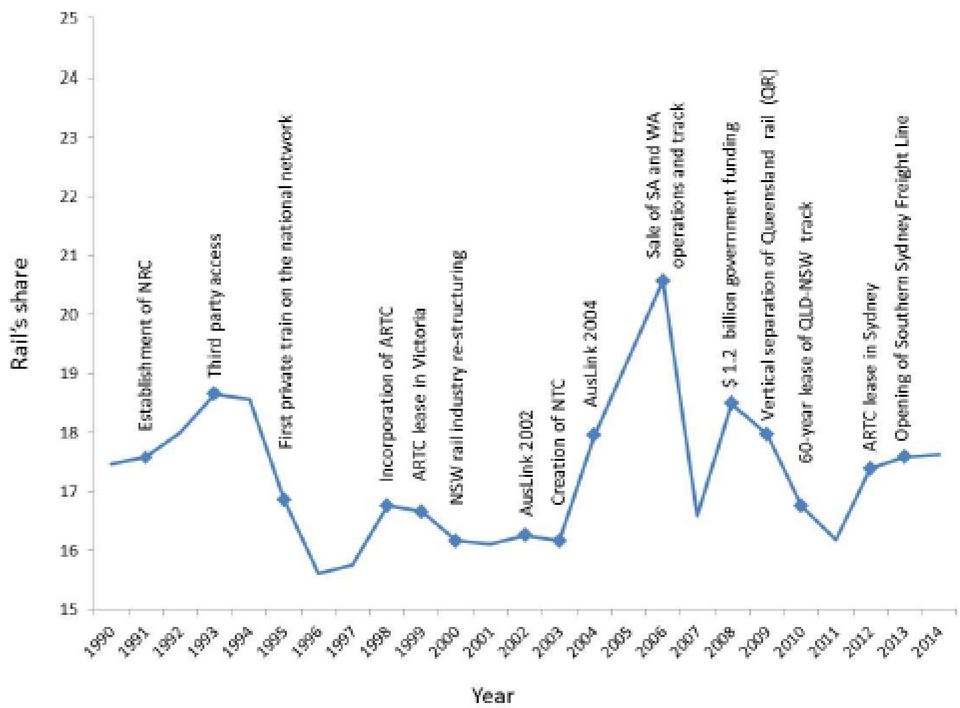

Figure 2. Changes in rail's comparative share to road with the relevant key events
Source: Authors

The key rail developments demonstrated in Figure 2 shows that government efforts to promote the use of rail and enhance integration had some positive influence on the rail sector, especially those in the early 1990s and early 2000s which are linked to the establishment of NRC and introduction of AusLink respectively. Nevertheless, poor implementation of those programs failed to introduce productivity into the market and after a short improvement rail's share started to decline.

Despite many reports undertaken by various government statutory bodies, there is little understanding of the key impediments to rail's competitiveness in Australia, particularly from the academic discipline. This is primarily due to the fact that, in the past, studies have been undertaken to achieve the vested interests of a particular stakeholder (mainly the one creating the report) rather than investigating the broader aspects of the rail sector. Thus, empirical research on this topic remains limited and demands further analysis. Furthermore, stakeholders' involvement in these studies is fractional and rail has not been studied according to its different sectors in Australia (bulk and non-bulk). Given the particular economic and social importance of the non-bulk rail freight sector, dedicated investigation is required. This research, therefore, is the first national study aiming to fill the empirical research gap in the Australian rail industry by systematically identifying the key stakeholders and evaluating their view using sophisticated analytical methods. This research follows a systematic literature review (SLR) to determine the factors that impede the competitiveness of the rail sector in Australia. As explained in (Ghaderi et al., 2015b), the SLR study identified impeding factors and industry challenges from 1,081 available industry reports on the Australian rail sector.

3. Data collection and methodological approach

A survey questionnaire was developed using the outcomes of the SLR. The result of the literature review was then refined to provide quality input for the questionnaire. The survey included questions evaluating the importance of impeding factors on the performance of the rail industry in the non-bulk freight market. The following key areas were covered in the survey:

i. *Infrastructure shortage*
ii. *Infrastructure management*
iii. *Interoperability and operational standards*
iv. *Infrastructure access charging regimes*
v. *Government policy and regulations*
vi. *Growth and modal shift*
vii. *Information sharing and data reliability*
viii. *Leadership and organisational factors*
ix. *Human factors and learning*
x. *Industrial relationship*

The survey was first pretested with the participation of peers and professionals from both academic and industry sectors, and the obtained comments and feedback were used to modify the questionnaire which underwent several revisions before being distributed. A stratified sampling strategy was used to develop the population under investigation. According to (Daniel, 2011), stratified sampling is more accurate than simple random sampling, and it generates a more representative sample with respect to each stratum (Onwuegbuzie and Collins, 2007). In addition, using online survey tools, the researchers can observe the response rate in each stratum (Fricker, 2008). The organisations' contact information was collected from the Australian Rail Directory and their websites. An invitation to participate in the survey was sent to potential participants using email invitations and LinkedIn messages. Since the personal contact information of participants was not publicly available, LinkedIn was used as a powerful tool to identify, contact and direct the participants to the online survey.

The operation of non-bulk rail freight involves the participation and collaboration of various operators, including above-rail operators, below-rail operators, terminal operators, ports and even the road sector as a competitor to rail. Understanding the dynamics of this system requires looking at the rail sector as a system with all its organisational ties and not only one player, such as train operator, track manager, terminal operator or the regulator. The notion of the rail stakeholder does not appear to have been previously defined in the body of literature. Therefore, this research takes a broader view of rail stakeholders to include various interest groups within the rail sector and its operational environment. Inspired by the concept of port stakeholders by Notteboom and Winkelmans (2002), this study categorises rail freight stakeholder as internal and external. Internal stakeholders are the entities directly involved in the operation of freight trains, including above-rail operators, below-rail operators (track and signalling), terminal operators, and engineering/maintenance firms. The external rail stakeholders include ports, warehousing and logistics operators, coastal shipping, the road sector, regulatory entities, government (as the policy maker) and sector representatives. This paper, therefore, is the first to ground the concept of rail stakeholders. This is a unique contribution of this paper as stakeholder identification and management is critical to the success of any industrial sector, particularly those in close interaction with society.

Once the key stakeholders were carefully identified, data were anonymously collected from 17 August to 17 September 2014. Of the 200 survey questionnaires sent out, 84 completed responses to the questionnaires were returned, generating a high response rate of 42.2 percent (Baruch and Holtom, 2008). Table 1 presents the profile of the survey participants, including the response rate.

Table 1. The profile of survey respondents

Sector	*Sector participants*	*Sector respondents*	*Response rate*	*Sector response portion*
Regulatory and policy making	28	18	64.3	21.4
Above-rail operation	51	18	35.3	21.4
Terminal operation	46	13	28	15.4
Consultation and engineering	24	12	50	14.3
Freight forwarding	17	10	59	12
Below-rail operation	14	7	50	8.3
Coastal shipping	4	2	50	2.4
Representative	4	2	50	2.4
Road haulage	10	1	1	1.2
Warehousing and logistics	2	1	50	1.2
Total	200	84	-	100

A total of 76.2 percent of the participating stakeholders were involved in the operations side, of which 21.4 percent were above-rail operators, and 8.3 percent were below-rail operations. Regulatory bodies and representatives together presented 23.8 percent of the total response rate.

Once the data were collected, exploratory factor analysis (EFA) was first conducted to identify the underlying factors against rail competitiveness. From then on, confirmatory factor analysis (CFA) was applied to statistically evaluate the relationships between the underlying factors determined from the EFA stage. The use of both EFA and CFA is preferred as it enables an effective approach to identifying and analysing the underlying factors from the many variables provided in the questionnaire (Thompson, 2004). This approach is beneficial to better understanding and prioritising the key impediments faced by different stakeholders in the market.

4. Analysis of results

Before explaining the results of the EFA and CFA, the descriptive statistics of respondents' answers to the seven-point Likert questions are presented in Table 2. The questions provided in this section were developed from the SLR and were scaled from 1 being 'not at all important' to 7 being 'extremely important'. All the mean values of the responses are significantly higher than the midpoint of the Likert scale (3.5), revealing that respondents are aware of the importance of the factors and their impact on their organisations' performance. In addition, an average measure in the last row reports the average of all respondents' answers to all questions. The mean value of 4.8/7 implies that the respondents are generally aware of the impeding factors and their applicability. In addition, the high mean values of the variables demonstrate the validity of the survey design and consequently the results of SLR.

Table 2. Descriptive statistics of variables influencing rail's competitiveness in Australia

Code	*Impediment*	*Mean*	*Std. Dev.*	*Skewness*	*Kurtosis*
I.1	Inadequate below rail infrastructure	5.4	1.5	-1.7	0.9
I.2	Inadequate intermodal terminal infrastructure	5.3	1.4	-1.2	1.8
I.3	Shortage of above rail infrastructure	5.1	1.5	-0.9	0.4
I.4	Rail's inability to provide door-to-door service	4.4	1.7	-0.7	-0.4
I.5	Poor interoperability between player	4.8	1.6	-1.0	0.3
I.6	Lack of national rail operations standards	4.6	1.5	-0.6	-0.3
I.7	Poor freight distribution systems	4.7	1.5	-1.1	0.7
I.8	Different types of pallets and containers	3.8	1.6	-0.2	-0.6
I.9	High terminal charges	4.7	1.7	-0.6	-0.2
I.10	Inefficient terminal operations	5.3	1.5	-1.2	1.0
I.11	Diverse management of infrastructure	4.7	1.5	-0.6	0.8
I.12	Inconsistent access charging regimes	4.8	1.7	-0.7	-0.4
I.13	Lack of common vision in government	5.3	1.3	-1.3	2.4
I.14	Lack of support from government	5.2	1.5	-0.9	0.7
I.15	Inconsistent public-private partnership policies	4.7	1.5	-0.7	0.4
I.16	Uncertainty about capacity for growth	4.9	1.6	-0.8	0.2
I.17	Diverse demand and growth patterns	5.0	1.5	-0.7	0.4
I.18	Shortage of reliable data on rail freight	4.7	1.5	-0.6	0.1
I.19	Poor information sharing and access	4.6	1.3	-0.5	0.6
I.20	Shortage of skilled human resource	4.9	1.4	-0.7	0.4
I.21	Over-regulation in the rail sector	4.9	1.3	-0.4	0.3
I.22	Slow adaption of technology in the rail sector	5.0	1.4	-0.8	0.5
I.23	Lack of integrated supply chain thinking	5.0	1.5	-1.2	1.0
I.24	Poor performance history of the rail sector	4.6	1.6	-0.5	-0.3
I.25	Poor customer relationship management	4.9	1.5	-0.6	0.1
I.26	Trade unions influence on productivity	4.8	1.7	-0.4	-0.6
I.27	Adversarial relationship between players	4.8	1.6	-0.6	0.2
	Average	4.8	1.5	-0.8	0.4

Before undertaking the EFA and CFA, a critical stage is to evaluate the quality of the sample (Williams et al., 2012). Therefore, tests of sampling adequacy and sphericity were conducted. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.840, significant at 1 percent significance level (p-value = 0.000). Similarly, Bartlett's test of sphericity is 632.7, significant at 1 percent significance level. Therefore, it can be concluded that there are correlations in the data set that are appropriate for factor analysis and the null hypothesis that the correlation matrix is identical is rejected (Dziuban and Shirkey, 1974).

Principal components method with the Varimax rotation method was applied for conducting the EFA. Johnson and Wichern (2014) explained that the choice of the number of common factors is based on a combination of (i) the proportion of the sample variance explained, (ii) subject-matter knowledge and (iii) the reasonableness of the results. Therefore, the Kaiser Criterion is used to determine the number of the principal components.

Table 3 presents the total variance explained by all of the factors associated with the responses obtained from stakeholders to 27 survey questions concerning the importance of impediments on rail's competitiveness. The first four underlying factors that are influential on performance have the eigenvalues of 6.435, 1.684, 1.203, 1.057 and 1.017 respectively, which equates to 76 percent of the total variance. Thus, according to the Kaiser Criterion only four factors can be retained for further analysis.

Table 3. Principal component analysis of impediments against rail competitiveness – Four factor model

Component	*Initial Eigenvalues*		
	Total	*% of variance*	*Cumulative %*
1	6.189	44.210	44.210
2	1.604	11.459	55.670
3	1.232	8.803	64.473
4	1.090	7.785	72.257
5	.750	5.355	77.612
6	.656	4.688	82.300
7	.580	4.144	86.444
8	.426	3.043	89.487
9	.348	2.486	91.973
10	.288	2.057	94.030
11	.264	1.884	95.914
12	.236	1.687	97.601
13	.177	1.264	98.866
14	.159	1.134	100.000

Extraction method: Principal component analysis

As reported in Table 3, the number of variables has been reduced from 27 to 14 in the EFA. Table 4 presents the rescaled rotated component matrix. Table 4. Rotated and rescaled component matrix

Variable	*Factors*			
	Infrastructure management	*Knowledge & Information sharing*	*Service delivery*	*Organisational & relationships*
I.9 High terminal charges	**.885**	-.006	.084	.216
I.10 Inefficient terminal operations	**.709**	.275	.076	.340
I.11 Diverse management of infrastructure	**.696**	.372	.290	.140
I.2 Inadequate intermodal terminal infrastructure	**.577**	.349	.317	.257
I.18 Shortage of reliable data on rail freight	.313	**.845**	.153	.112
I.19 Poor information sharing and access	.081	**.811**	.184	.285
I.16 Uncertainty about capacity for growth	.187	**.777**	.259	-.017
I.24 Poor performance history of the rail sector	.086	.163	**.861**	-.013
I.25 Poor customer relationship management	.049	.149	**.813**	.341
I.4 Rail's inability to provide door-to-door service	.362	.205	**.618**	.076
I.7 Poor freight distribution systems	.520	.326	**.589**	.062
I.27 Adversarial relationship between players	.262	.067	.216	**.845**
I.26 Trade union influence on productivity	.214	.031	.035	**.821**
I.20 Shortage of skilled human resource	.126	.366	.075	**.567**
Cronbach's Alpha	.848	.846	.819	.731

Extraction method: principal component analysis
Rotation method: Varimax with Kaiser normalisation
A: Rotation converged in seven iterations
Source: Author's estimation, SPSS 21 output

As indicated by the loading values in Table 4, the first factor is infrastructure management which is associated with high terminal charges (0.885), inefficient terminal operations (0.709), diverse management of infrastructure (0.696) and inadequate intermodal terminal infrastructure (0.577). The higher loading of variables in this group suggests that the performance of the rail sector in Australia is strongly under the influence of factors related to infrastructure management. The second factor, referring to knowledge and information sharing, is associated with the shortage of reliable data in rail freight (0.845), poor information sharing and access (0.811) and uncertainty about capacity for growth (0.777). These results suggest that data reliability and availability are key determinants for the effective operations of the non-bulk rail freight sector. The third factor includes variables associated with service delivery such as poor performance history of the rail sector (0.861), poor customer relationship management (0.813), rail's inability to provide door-to-door service (0.618) and existence of poor freight distribution systems in Australia (0.589). The fourth factor is associated with organisational communications and commercial relationships within the rail industry. This factor includes adversarial relationships between different players in the non-bulk freight market (0.845), the influence of trade unions on productivity (0.821) and shortage of skilled human resources (0.567). The last row of Table 4 reports the Cronbach's Alpha coefficient, used for the reliability test as recommended by Meyers et al. (2013). The values of the Cronbach's Alpha coefficient for the factors obtained from the EFA are 0.848, 0.846, 0.819 and 0.731. These values indicate a relatively high level of reliability such that the variables identified are more likely measuring the same construct.

CFA was subsequently conducted to further analyse the relationships between the underlying factors identified in the EFA stage. In the CFA stage, all the possible relationships between the underlying factors are first identified and evaluated based only on the variables with significant relationships. AMOS 21 was used to conduct the CFA in this part. Figure 3 demonstrates all the possible relationships between the underlying factors derived from the EFA with the standard estimates of the regression coefficients respectively. The relationships between variables are indicated by covariance estimates.

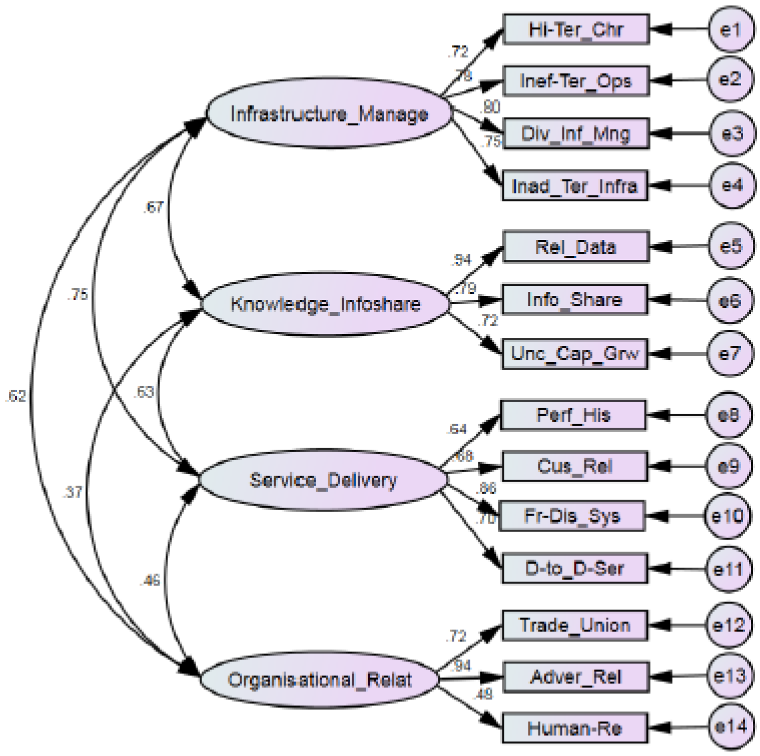

Figure 3. Path diagram with standardised estimates for the all relationships (model fit)
Source: Authors' estimation, AMOS 21 output

Table 5 presents the regression weights estimated from the AMOS 21 output. The estimates strongly indicate that all variables are significant at the one percent significance level.

Table 5. CFA analysis for the model fit (See Figure 3)

	Variable		*Factor*	*Estimate*	*S.E.*	*C.R.*	*P*
I.10	Inefficient terminal operations	<--	Infrastructure management	1			***
I.2	Inadequate intermodal terminal infrastructure	<--	Infrastructure management	0.886	0.128	6.936	***
I.11	Diverse management of infrastructure	<--	Infrastructure management	1.015	0.136	7.469	***
I.9	High terminal charges	<--	Infrastructure management	1.030	0.156	6.617	***
I.18	Shortage of reliable data on rail freight	<--	Knowledge and information sharing	1			***
I.19	Poor information sharing and access	<--	Knowledge and information sharing	0.729	0.85	8.598	***
I.16	Uncertainty about capacity for growth	<--	Knowledge and information sharing	0.830	0.109	7.604	***
I.7	Poor freight distribution systems	<--	Service delivery	1			***
I.4	Rail's inability to provide door-to-door service	<--	Service delivery	0.879	0.148	5.958	***
I.24	Poor performance history of the rail sector	<--	Service delivery	0.783	0.130	6.023	***
I.25	Poor customer relationship management	<--	Service delivery	0.780	0.122	6.409	***
I.26	Trade union influence on productivity	<--	Organisational and relationships	1			***
I.27	Adversarial relationship between players	<--	Organisational and relationships	1.199	0.200	6.001	***
I.18	Shortage of skilled human resource	<--	Organisational and relationships	0.571	1.136	4.189	***

S.E : Standard Error
C.R: Critical Ratio

Source: Authors' estimation, AMOS 21 output

However, from the CFA analysis the current large value of the Chi-square statistic (CMIN/DF = 1.875), and the root mean square error of approximation (RMSEA = 0.103) indicate that modification of the initial model is necessary. Therefore, variables with low loadings are first excluded (Curran et al., 1996, DiStefano, 2002), and based on the values of standardised residual covariance variables with higher residual covariance (which are above 0.4) are excluded in repeated trials. Figure 4 shows the path diagram with standardised estimates for the modified model. This process is critical to identify strong relationships and establish specific paths between variables (Markus, 2012).

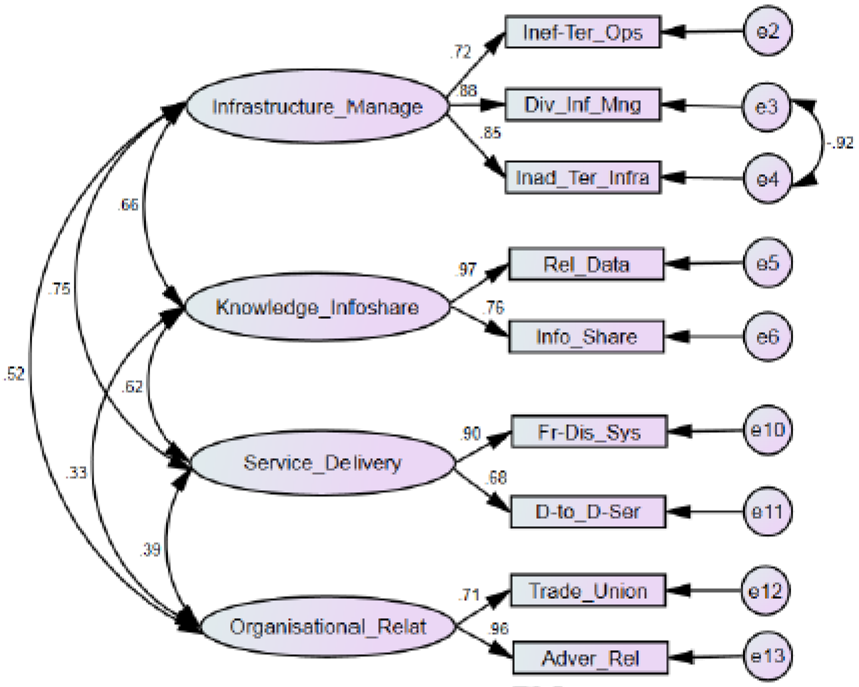

Figure 4. Path diagram with standardised estimates for the significant relationships (model fit)
Source: Authors' estimation, AMOS 21 output

As shown in Table 6, all the variables in the modified model are significant. Furthermore, although their values are mainly outside the desirable ranges, both the Chi-square statistic (CMIN/DF) and the RMSEA a have improved significantly from the original model with their values being 0.986 and 0.000 respectively. PCLOSE associated to RMSEA is 0.700 which suggests that, consistent with the EFA output of four factors, CFA produces the same model of four factors influential on the competitiveness of the Australian rail sector, including infrastructure management, knowledge and information sharing, service delivery and organisational and relationship factors.

Table 6. CFA analysis for the modified model fit (See Figure 4)

	Variable		*Factor*	*Estimate*	*S.E.*	*C.R*	*P*
I.10	Inefficient terminal operations	<--	Infrastructure management	1			***
I.2	Inadequate intermodal terminal infrastructure	<--	Infrastructure management	1.078	0.168	6.423	***
I.11	Diverse management of infrastructure	<--	Infrastructure management	1.198	0.180	6.645	***
I.18	Shortage of reliable data on rail freight	<--	Knowledge and information sharing	1			***
I.19	Poor information sharing and access	<--	Knowledge and information sharing	0.681	0.097	7.046	***
I.7	Poor freight distribution systems	<--	Service delivery	1			***
I.4	Rail's inability to provide door-to-door service	<--	Service delivery	0.879	0.148	5.958	***
I.26	Trade union influence on productivity	<--	Organisational and relationships	1			***
I.27	Adversarial relationship between players	<--	Organisational and relationships	1.232	0.274	4.497	***

S.E : Standard Error
C.R: Critical Ratio

Source: Authors' estimation, AMOS 21 output

5. Discussion of results

During the CFA analysis, high terminal charges (under infrastructure management), uncertainty about capacity for growth (under knowledge and information sharing), poor performance history of the rail sector and poor customer relationship management (under service delivery) and shortage of skilled human resources (under organisational and relationships) were removed. This result suggests that the detached factors are less of an impediment to the performance of the rail sector in the non-bulk freight market. In addition, the error term of I.11 as diverse management of infrastructure (e3) and the error term of I.1 as inadequate intermodal terminal infrastructure (e4) have a strong relationship (-0.92). This may indicate that poor infrastructure management results in the under-utilisation of assets.

This paper does, however, recognise four key impeding areas impacting on the competitiveness of the rail sector in Australia, including (i) infrastructure management, (ii) shortage of freight data and poor information sharing, (iii) service delivery and (iv) organisational communications and commercial relationships, each of which are discussed in the following sub-sections.

5.1 Infrastructure management

Infrastructure is the key input of a rail freight transport system (Hensher et al., 2012). Three essential elements are associated with an infrastructure management system: provision, operations and management. As discussed in Section 2, a number of track upgrades have been put into action by both private and public sectors, including new lines and standardisation of current tracks, which has resulted in enhanced integration. However, the provision of an intermodal terminal infrastructure has lagged behind the freight demand growth in Australia over the past three decades. This issue is considered as a key impediment to the competitiveness of rail by various stakeholders. Furthermore, most of the intermodal infrastructure (specifically terminals) in Australia are poorly designed, improperly located and outdated technologies are in place (Shipping Australia, 2011). These issues have been continuously been deteriorating the productivity of the rail sector. Due to the significant gauge differences and low freight volumes in regional areas, the efficiency of intermodal terminals is a critical success factor in ensuring the commercial viability of the rail sector. This is mainly because the efficiency of terminal handling operations is strongly linked with the total freight cost and time-based elements of an intermodal freight service.

Diverse management of infrastructure is another key concern for the Australian rail sector. The management and ownership of rail infrastructure is diverse and complex. As discussed earlier, although the nationally significant rail infrastructure (such as the interstate network) is owned and managed by the federal government, freight trains travel through different types of infrastructure (intermodal terminals and regional railways for example) which is owned or managed by the public or private sectors, including a State government or a commercial operator. Complex ownership and management of rail infrastructure together with different access regimes in practice have triggered numerous disputes between the infrastructure managers and train operators over the recent years. These conflicts often result in severe debates with government intervention, interruption of operations and its subsequent costs. As rail is heavily under pressure from the road sector, any stoppage of the network results in losing financial resources and customers. Therefore, seamless and efficient operations of freight trains require an integrated infrastructure management across the entire network and not only the line-haul component.

5.2 Shortage of freight data and poor information sharing

More than ever, the transportation industry is moving towards an information-based environment (Strocko and Conway, 2012). The efficiency and effectiveness of a freight system strongly relies on reliable information (Pratt et al., 2012). According to the United States Transportation Research Board (2003, p.5), 'reliable, consistent, comprehensive and timely data on freight movements are essential for informed decision making in government and the private sector, for both economic and infrastructure investment decisions and for policy'. Following the growth in the number and scale of private rail operators as the result of the rail deregulation process, there has been a significant decrease in the availability and quality of rail freight data, particularly on the intermodal rail market. Specifically, the intermodal supply chains in Australia are continuing to operate largely on the basis of poorly integrated information flows and weak information processes (GS1, 2015). This has resulted in serious concerns from different stakeholders on the quality and accessibility of freight data available to the rail sector in Australia. Most of the data used for making rail freight policy and planning decisions are incomplete, outdated and unreliable. The freight sector, which needs data for operational, planning and policy making purposes, encounters difficulties associated not only with the fragmented nature of freight data but also with the cost involved in locating, accessing and employing those data (CSIRO, 2005). In addition to generating quality freight data, information sharing is essential for a freight system to be flexible and responsive. Many rail freight operators are reluctant to share information with their trading partners, principally because of (i) different information technology interfaces, (ii) the cost associated with sharing the information and (iii) the risk that the information will be used against them.

From a policy perspective, the lack of detailed and timely rail freight data is a significant issue for government's transportation and infrastructure related organisations (such as the Bureau of Infrastructure, Transport and Regional Economics (BITRE) and NTC in their pivotal role in providing information and advice to different levels of government on freight transport decisions. In particular, accurate and timely rail freight data are a key input to the AusLink long-term planning and decision making needs (BTRE, 2007). Therefore, the rail sector can significantly benefit from the development of a national freight data system that provides efficient collection, processing and distribution of data among various parties.

Whilst the industry has expressed its concerns on these matters (GS1, 2015), there has been no individual, group or business who has taken responsibility on behalf of industry to develop a transparent, user friendly and unified system for use by industry and relevant stakeholders. Therefore, this requires the active involvement of government, as the leader and regulator, to increase the awareness of the rail sector regarding the importance and applicability of such systems on their operational and planning decision making processes.

5.3 Service delivery

Non-bulk freight movements demonstrate considerably more diversity and complexity than other types of freight in regards to a distribution network, delivery and customer requirements (BITRE, 2009), including various forms of warehousing and value-adding logistics activities. For the non-bulk freight movements, it is the door-to-door service that matters to the freight customers, rather than the line-haul components of the trip. Rail transport is naturally restricted to provide this and road plays the complementary tasks of pick-up and delivery across the distribution systems. While this is an inevitable and natural impediment, for many types of freight rail's efficiency and effectiveness over long distances reimburse the low degree of flexibility. This means that the quality of an intermodal freight service involving rail is determined by the efficiency of the entire distribution network.

However, poor freight distribution systems are significantly affecting the quality of the intermodal service delivery for the freight customers. Non-bulk freight flows in Australia predominantly consist of two major sub-markets; the freight carrying between ports and ports' hinterland (generally intermodal), and those generated from domestic production facilities and carried interstate and/or intrastate to the final customer, including both intermodal and less-than-truckload movements (Ghaderi et al., 2015a). At this time there are major interoperability impediments in regards to the landside distribution of freight and the interfaces between different transport operators and distribution centres. These include (i) access agreements to the intermodal terminals, (ii) congestion on the main rail and road corridors to key distribution facilities (Booz & Co, 2009) and (iii) mismatch of operating hours between terminal operators, distribution centres, transport operators and customers (Shipping Australia, 2011), which all leads to poor quality of intermodal service and subsequent interest of freight customers to use a road-only service. The discussions arising from this paper and the reviewed literature reveal that several inefficiencies exist across the intermodal distribution systems in Australia. Furthermore, there is recognition from both industry and government that if the existing distribution systems do not effectively handle the current demand, how they will accommodate the growing freight demand over the next two decades. As the available infrastructure is already congested (especially ports and key intermodal terminals), the importance of coordination and interoperability between different players involved in undertaking the freight task becomes considerably prominent.

5.4 Organisational communications and commercial relationships

The overall efficiency and competitiveness of any system is determined by the degree in which its mechanisms communicate and collaborate together (Childerhouse et al., 2011). In this context, the operation of the intermodal freight task is complex in nature, comprising participation of various operators and regulators as complements, and sometimes as competitors. This means the quality of the overall door-to-door intermodal service is not only determined by the performance of train operators, but the extent to which collaboration exists across the entire logistics chain. The deregulation of the rail sector and vertical separation of above-rail and below-rail operations introduced competition into the market, but it has definitely failed to bring integration as it created one of the world's most complex rail industry structures. This complexity increased excessive bureaucracy and ambiguity, but also formed a system in which collaboration and coordination are unfamiliar concepts across the rail industry. The structure of the Australian rail sector has created communication deficiencies and adversarial relationships between key players to the detriment of overall industry efficiency. The ongoing number of disputes between the above-rail and below-rail operators is evidence of such an environment. Commercial disputes have become common rail sector challenges over the past three decades. A good example is the recent clash between

24

CBH Group and Brookfield Rail in Western Australia which resulted in numerous government intervention (PWA, 2014).

Another issue raised by the stakeholders in the survey is the influence of unions on rail's productivity. Although the Australian rail industry is no longer the completely unionised sector that it used to be, unions still have a great influence on productivity. The majority of the workforce employed by the freight sector (especially in the intermodal terminals) is heavily unionised and rail freight operators need to more vigorously tackle union resistance to a range of potential work practice changes (JHC, 2008). From a port perspective, the key stevedores in Australia (as the main cargo generators for the rail sector) are members of the Maritime Union of Australia (MUA). This multifarious working environment has led to several strikes and stoppages of terminal operations in the last two decades, such as the 1998 Australian Waterfront Dispute. Therefore, a more mature approach is required across the rail industry to overcome these challenges by understanding the mutual benefits that can be achieved through collaboration.

6. Conclusion

What is evident from this paper is that there are a number of impediments impacting on the competitiveness, efficiency and profitability of the rail sector, particularly in the non-bulk freight market. Despite a number of attempts by government, policy makers and operators to bring about change, there is still much to be done to increase the attractiveness of rail as a competitor (and even a collaborator) to road. Changes are required as to how rail is operated in Australia as factors such as congestion and concern about emissions are impacting on the overall transport efficiency and Australia's economic competitiveness in international markets. For example, this paper suggests the performance of the rail sector is influenced by infrastructure management, and that the intermodal terminal infrastructure still lags behind the freight demand growth.

This paper has adopted an empirical approach from which to examine the Australian rail sector which has resulted in a broader approach being taken to the notion of rail stakeholders. Through the use of EFA and CFA, this paper found four factors that are impeding rail development, these being infrastructure management, shortage of freight data and poor information sharing, service delivery, and organisational and commercial interactions. The findings provide important implications for both industry and government in terms of making transport planning and policy decisions. From a policy perspective this paper provides useful insights by identifying the weak parts of the rail sector and directions to target them. In addition, the use of EFA and CFA is recommended for future studies as it was found to be valuable in identifying factors from the many variables presented in the online survey.

Besides the need for greater policy development and government involvement to improve rail productivity and integration, greater interest from an academic perspective is required. As this paper highlights, there is a paucity of academic research on rail, which is critical infrastructure in Australia. Emphasis is also required on developing an integrated freight system that includes rail, road, sea and air. For this to be accomplished, a far more strategic understanding of the benefits that rail can provide will be required.

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APPENDIX A-3 – Paper III

Factors Affecting the Competitiveness of the Australian Rail Sector: A Systems Approach to Improving Service Quality

Hadi Ghaderi, Stephen Cahoon and Hong-Oanh Nguyen

hghaderi@amc.edu.au

Department of Maritime and Logistics Management, National Centre for Ports and Shipping, Australian Maritime College, Launceston, Tasmania, Australia

1. Introduction and the rationale for this research

Freight is an essential element of the Australian economy and a critical sector for the future growth of the nation. Therefore, a robust freight transport system that is sustainable, efficient and safe is necessary to maintain Australia's international competitiveness. Total freight volumes have quadrupled over the past decades (BITRE, 2014a) largely due to: (i) significant growth in mining activity, (ii) increased domestic and international trade, and (iii) an increasing population (Ghaderi et al., 2015a). In 2011–12, total domestic freight activity was almost 600 billion kilometers which is equivalent to 26,000 ton kilometers[1] (tkm) of freight carried for every person in Australia (BITRE, 2014b). This continuing growth has however posed complex challenges to government and industry in their planning and infrastructure decision making.

Australian freight activity can be generally categorized into two: bulk and non-bulk. Australia's bulk freight market is dominated by rail transport due to its inherent cost effectiveness and economies of scale, of which an exemplar is the rail transport of coal and iron ore from mines in Western Australia and Queensland to their nearest ports for export. Rail is also involved in transporting smaller quantities of minerals and grains to ports. A benefit of the

[1] One ton kilometer is equivalent to one ton moved one kilometer

growth in mining activities has been the access to capital for the development of rail infrastructure, and accordingly greater rail freight activity (BITRE, 2012).

However, the circumstances are comparatively different in the non-bulk[2] freight sector. The non-bulk freight sector comprises a complex system of consumers, retailers, distributors, transport operators, logistics facilities, suppliers and demand all of which have a significant impact on the wider community in Australia (Wijeweera et al., 2014). Where the movements of goods in the bulk markets typically take place in regional areas, the non-bulk freight activity is tied with the daily life of society (Santos et al., 2015). Non-bulk freight is generally recognized as containerized or other unitized freight, including trailers and imported vehicles. This freight segment demonstrates more diversity and complexity than bulk freight in terms of packaging, distribution networks and the delivery requirements (BITRE, 2009). The total value of the non-bulk supply chains equated to around two percent of Australia's gross domestic product (GDP) in 2008[3], of which the interstate corridors comprised 61 percent, port-based systems 34 percent, and the intrastate chains five percent (Booz & Co, 2008). Interstate freight corridors are the primary market segment in Australia where the competition between road and rail is most evident.

In the non-bulk freight sector, modal shares on various routes reflect the relative competitiveness of the different transport modes (Vasco, 2014). However, poor service quality is regarded as the major reason for the lower use of rail in the domestic market (ARTC, 2015). On the North-South rail corridor (Brisbane-Sydney-Melbourne) where the major non-bulk freight volumes travel, the on-time reliability until recently has been declining from 2011, varying between 20 to 80 percent compared with road's 95 to 98

[2] In this paper non-bulk and intermodal freight deliver the same meaning.
[3] Transport economic-based data on the domestic freight task are not regularly generated; these are the most current data available.

percent. The situation is comparatively more stable in the East-West corridor where rail's reliability has remained between 40 to 80 percent (BITRE, 2014c). This is mainly because transporting goods by rail is dependent on other elements of intermodal system, including connecting transport modes and logistics centers such as intermodal terminals. Figure 1 demonstrated the railway network used for the Australian non-bulk movements.

Figure 1. Network used for non-bulk rail freight (BITRE, 2012, p.4)

As the result of poor service quality, rail's share in the non-bulk market has remained around 17 percent over the past two decades (BITRE, 2014a). Figure 2 demonstrates the comparative task (in billion tkm) of road and rail in the non-bulk freight market from 1995 to 2014. It should be noted that a small volume of non-bulk freight is carried by sea, mainly between Melbourne and Tasmania where there is no land-based connectivity.

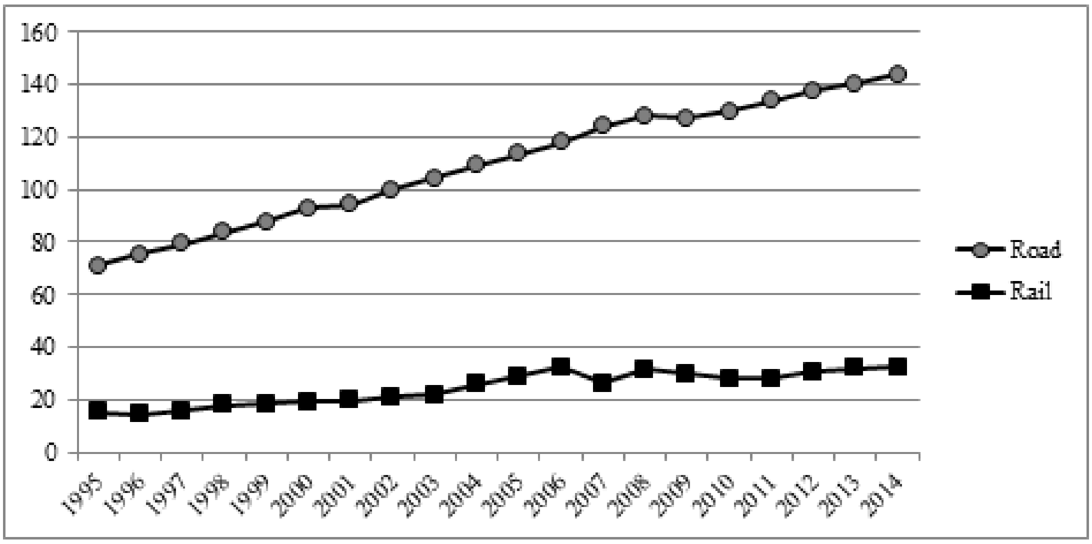

Figure 2. Comparative share of road and rail from 1995 to 2014

Source: Bureau of Infrastructure, Transport and Regional Economics (BITRE) (2014a)

According to Ghaderi et al. (2015b) the productivity and competitiveness of rail transport in Australia is hampered by various impediments. These include infrastructure constraints, commercial barriers, and inconsistent standards and policy, all of which influence the quality attributes of the rail freight service in different ways. Therefore, in order to develop strategies to make rail an attractive mode of transport in the non-bulk freight market, it is critical to identify these impediments and assess their relevant influence on the quality of rail service.

This research therefore, aims to empirically examine the impact of impediments faced by the rail sector in Australia on the key freight service attributes (FSA). To meet this objective, an in-depth survey was developed to evaluate the knowledge of rail stakeholders on the key challenges and their applicability on the quality of rail freight service. Accordingly, descriptive and inferential statistical analyses were conducted to explore the view of stakeholders on the identified factors. This approach is beneficial as it: (i) identifies the distinct impact of each impediment on the different FSAs; (ii) provides important insights to improve the rail service quality; and (iii) aims to assist government and industry to develop informed transportation and infrastructure planning decision making by identifying the poorer performing areas of the system. The organization of this paper is as follows: section 2 presents a brief literature review on the subject of freight mode choice within both the international and Australian context, followed by section 3 that explains the importance of a systematic study of the rail sector and the underlying theoretical framework of this research. The purpose of section 4 is to detail the methodological approach for the paper, including the data collection, while the analysis and subsequent discussions are presented in sections 5 and 6 respectively. In the final section, conclusions are presented and recommendations are provided for improving the quality of the Australia rail freight services.

2. Factors influencing the customer's choice of freight transport mode

Over the past three decades there has been increasing attention on the area of freight mode choice and the identification of the key factors influencing the choice of transport mode (Shinghal and Fowkes, 2002, Lu, 2003, Danielis et al., 2005, Meixell and Norbis, 2008; Yang et al., 2014). Many researchers believe that having a clear understanding of these factors is essential for the development of competitive services in freight transport markets. (Saranen and Hilmola, 2007; Yu et al., 2013),

The demand for freight service is value-driven. In this sense, the customer's choice of transport service involves a complex trade-off between various key monetary and non-monetary factors such as freight rate, transit time, reliability and service availability (Begantino et al, 2013; Arencibia et al., 2015). Therefore, the determining factor for a modal shift is whether and to what extent the different modes are able to adapt to the changing requirements of the transport industry (OECD, 2010). Woxenius and Bärthel (2008) argue that the choice of transport solutions for freight is more multifaceted compared to passenger systems as it involves a greater number of actors (for example trucks, rail transport, intermodal terminals and storage facilities), with different values, perceptions and goals.

Flodén et al. (2010) argue that understanding the factors behind the choice of freight transport mode is vital for various reasons. First, from a society perspective, the information can be used for infrastructure planning and investments. Secondly, from a service provider perspective, the information can be used to develop marketing and transport management solutions that consequently enhance the competitiveness of the particular transport mode (Edwards et al., 2001).

Historically, transportation mode choice was a simple process where the door-to-door freight cost was the dominating decision making factor. Nowadays, mode choice and carrier selection are becoming part of the complex decision-making process in transportation management that includes identifying relevant transportation performance variables, selecting the mode of transport and carrier, negotiating rates and service levels, and evaluating carrier performance (Murphy and Poist, 2000, Monczka et al., 2008). Accordingly, there has been an increasing amount of research dedicated to development of methodologies to understand the complexity of transportation mode choice (Mehbub Anwar et al., 2014).

According to Flodén et al. (2010) and Grosso (2011), two main typologies of influential factors on a customer's choice of transport mode can be identified: cost variables and time-based variables. For a door-to-door service the cost factor is determined by the total freight rate, where the time-based attributes are reflected as: (i) transit-time, (ii) reliability (punctuality) and (iii) service availability. Although some other factors can be identified from the literature, they can be indirectly categorized under the key factors mentioned above. For example, damage and loss are normally categorized under freight rate. In addition to these key factors, the environmental impact of freight services has recently received attention in the area of freight mode choice (Witlox and Vandaele, 2005). However, tools such as carbon tax pricing are instrumental to internalize the associated environmental costs into the freight rate factor (Fahimnia et al., 2013, Meng et al., 2013).

Historically, the freight rate was the most important factor influencing the choice of transport mode (Morash and Ozment, 1996). Over the past three decades, the adoption of lean production and just-in-time principles in manufacturing (Fowkes et al., 2004, Kuo and Miller-Hooks, 2012) has resulted in smaller volume flows of freight being delivered at more frequent intervals, thus reducing the transport efficiency of companies supplying these customers (Woodburn, 2003). One way to reduce the inventory cost without lowering the service level is to have better control over the variability of lead times (Ghaderi and Dullaert, 2012). Also, with rapid development in product globalization and just-in-time production over the last two decades, customer-oriented freight services are of increasing interest and demand (Hanaoka et al., 2011). Highly responsive networks for fast-moving consumer goods (FMCG) and the automotive industry, for example, illustrate the pressure to better manage inventories by increasing the use of the reliable and faster freight services. Consequently, the time-based attributes of a freight service such as transit-time and reliability have gained momentum as a result of increased attention from academia and industry (Saldanha et al., 2009, Van Oort and van Nes, 2010, Berger et al., 2011, Feo et al., 2011, Landex, 2012). Time-based transportation strategies can be relevant and important for freight operators to gain competitive advantage and to provide customer value (Morash and Ozment, 1996). Typically, these strategies are about managing the important sources of customer value that are associated with the time-based attributes of a transportation service.

As a result of changes in the freight distribution requirements, it is clear that the operational scope for rail becomes limited in its ability to compete with the more responsive road transport. The limited playing field for rail is evident in Australia due to its disparate population distribution of consumers separated by long distances (Ghaderi et al., 2015a). The Australian freight forwarding industry also broadly delineates freight types according to time-based and cost attributes (BITRE, 2009). Therefore, in this paper the competitiveness of a freight service in Australia is determined from the abovementioned four factors. This approach is pivotal in shaping the theoretical framework of this research.

3. Theoretical framework

The non-bulk rail sector is a complex industrial system in terms of operations, policy, regulation and structure (Woodburn, 2008, ARA, 2010). Therefore, the extent to which different elements of the non-bulk rail sector are orchestrated, substantially determines its performance and competitiveness in the freight market (Allen et al., 2010).

The literature on rail competitiveness is scarce and tends to be unsystematically generated. The literature consists of studies that are either explaining rail's declining share in different markets from a service-levels perspective (Shinghal and Fowkes, 2002, Brooks et al., 2012), including the freight rate (Shinghal, 2005), reliability levels (Kaas, 2000, Vromans et al., 2006), service availability and transit time (Kanafani et al., 2012); or focusing only on a single element of this complex system. This stream of research for example, focuses on access pricing (Everett, 2005), competition (Behrens and Pels, 2012), infrastructure management (Crozet, 2004), regulations (Cantos and Maudos, 2001, Spychalski and Swan, 2004), policy (Everett, 2006, Dablanc, 2009), funding (Hensher et al., 2012), industry structure (Woxenius and Bärthel, 2002, Williams et al., 2005), environmental impact

(Feitelson, 1994) and operational practices (Peng et al., 2013). Due to the dynamic and complex interrelationships between different mechanisms of the rail sector, strategies that aim to improve a particular aspect without examining the consequent impacts on other areas are not necessarily practical (Tsamboulas et al., 2007). For example, a proposed pricing system may increase the freight rate of a competing transport mode, but can fail to meet the service requirements when interfacing with the rail system.

In addition to the current approach of studying rail competiveness, the operation of non-bulk rail freight is a complex task involving the participation and collaboration of various stakeholders, including above-rail operators, below-rail operators, terminal operators, ports and even the road sector. Therefore, understanding the dynamics of this system requires viewing the rail sector as a system with many organizational ties and actors, including the train operator, track manager, terminal operations and regulator.

This fragmentation in rail competitiveness research has resulted in the shortage of a strong and comprehensive theoretical framework in which different aspects of the rail sector are covered to assess the overall competitiveness of the sector. Therefore, this paper proposes a systems approach for the rail sector in order to identify, evaluate and priorities the key industry challenges and to enable the industry and government to make informed policy, planning and infrastructure decision making. The systems approach developed in this paper is beneficial to investigating the rail sector as a single system while understanding its position in the broader freight market environment.

A systems approach often refers to three key components: inputs, process and output, which this paper applies to the rail sector (Berrien, 1976). According to Jackson (2000), the primary sub-systems of an organization are mainly: the goal (outcome), tangible resources and technical, human and managerial practices which can be categorized as inputs and process respectively. Therefore, inputs can be defined as tangible and intangible assets, whereas both can be translated into assets for a business sector. In a large-scale sector such as rail, assets are numerous due to the multiplicity and interfaces of operations. For example, operations of freight trains are complex with involvement of various supply chain actors and their assets. The assets mainly include below-rail and above-rail infrastructure, intermodal terminals, handling facilities, skilled human resources, financial resources and the required technology to advance.

The second component of the rail system is the process. In a business sector, process can be defined as the practice or know-how of employing the assets to achieve the outcomes (Jackson, 2000). Processes are sometimes developed and implemented by the firms operating in the sector, or as the collective decision of firms under a union or association. Process can also be defined as the policies developed and implemented by the government which controls the market to ensure the economy is free from disorder. In the rail sector, processes mainly include operational practices, regulations, policy, marketing and training. This for example, includes the operational and safety procedures of running freight trains in different parts of the network.

Another major emphasis of this systems approach is on the throughput concept as the processing of production input to yield outcomes that are used by the external environment (Cetin and Cerit, 2010). In other words, the interaction of organizations with their internal resources and the changing external environment requires attention to growth, resource acquisition and external support (Quinn and Rohrbaugh, 1983). This is linked with the third element of Systems approach called output. In this sense, the rail sector is a system interacting with other freight actors which uses/utilizes resources such as below rail infrastructure and intermodal terminals to provide freight service as the output. In addition, due to the complexity of the rail sector, a systems approach is beneficial to effectively analyse the great number of interactions and actors as a single arrangement and to evaluate its overall competitiveness.

According to the competitiveness concept, the assets and processes are the organizational capabilities to create the outputs (Feurer and Chaharbaghi, 1994). In this sense, the rail sector employs both tangible and intangible assets using the operational practices under certain regulations and policies to create a freight transport service for the customers. Assets and processes are strongly interrelated. The extent to which assets and processes complement each other determines the quality of rail freight services and consequently the competitiveness of the rail sector. Subsequently, feedback from the customers and competing transport modes are systematically linked back to the rail sector for improvement decisions.

The development of the conceptual framework in this paper consists of two stages. First, the systems approach is applied to the competitiveness concept by combining the input and process components of a system to organizational capabilities. The systems approach to competitiveness is then applied to the rail sector.

In the systems approach to competitiveness, rail sector's capabilities aim to create a competitive service in the non-bulk freight market. As shown in Figure 2, assets and processes as the capabilities are in interaction and the feedback from the market is returned the sector for improvement and decision making. This conceptual framework constructs the road map to study the competitiveness of the rail sector by identifying the impediments and evaluating their impacts on the output of the sector and to provide strategies to improve the freight service.

According to the competitiveness concept, the assets and processes are the organizational capabilities to create the outputs (Feurer and Chaharbaghi, 1994). In this sense, the rail sector employs both tangible and intangible assets using the operational practices under certain regulations and policies to create a freight transport service for the customers. Assets and processes are strongly interrelated. The extent to which assets and processes complement each other determines the quality of rail freight services and consequently the competitiveness of the rail sector. Subsequently, feedback from the customers and competing transport modes are systematically linked back to the rail sector for improvement decisions.

The development of the conceptual framework in this paper consists of two stages. First, the systems approach is applied to the competitiveness concept by combining the input and process components of a system to organizational capabilities. The systems approach to competitiveness is then applied to the rail sector.

In the systems approach to competitiveness, rail sector's capabilities aim to create a competitive service in the non-bulk freight market. As shown in Figure 2, assets and processes as the capabilities are in interaction and the feedback from the market is returned the sector for improvement and decision making. This conceptual framework constructs the road map to study the competitiveness of the rail sector by identifying the impediments and evaluating their impacts on the output of the sector and to provide strategies to improve the freight service.

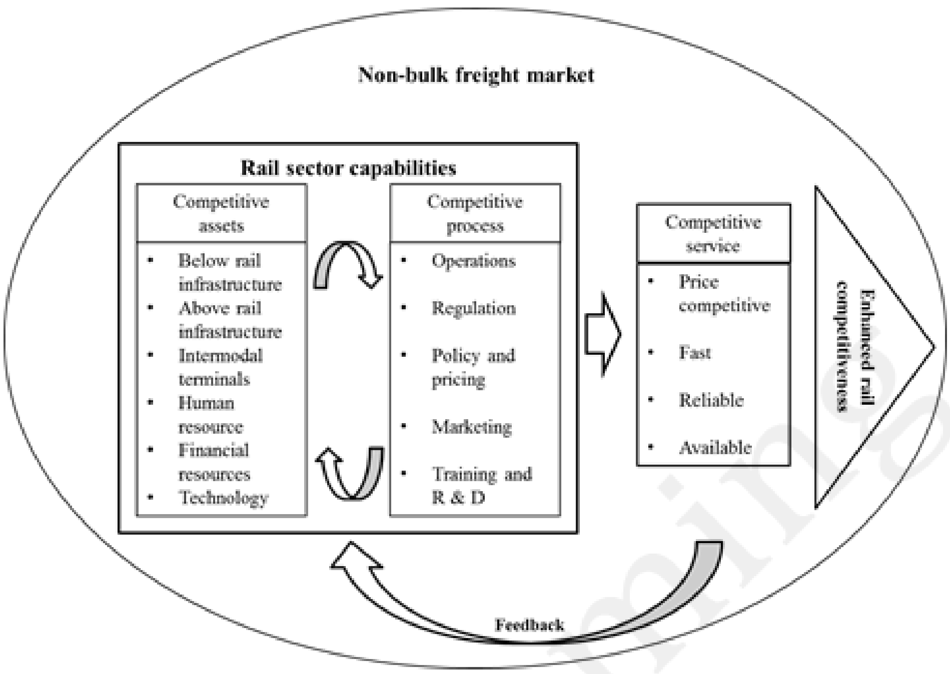

Figure 2. A systems approach model to enhance rail competitiveness

Source: Authors

Considering the objective of this paper, applying a systems approach to the rail sector is beneficial to linking the impeding factors associated with the organizational capabilities of the rail sector and evaluating those factors in relation to the competitiveness of the freight service. The following section presents the empirical approach adopted in this paper.

4. Methodological approach

An in-depth survey was designed based on the outcomes of a systematic literature review (SLR) carried out by the authors to identify the factors impeding the competitiveness of the rail sector in Australia (Ghaderi et al., 2015b). The survey included questions evaluating the importance of impeding factors to the different attributes of rail freight service, including freight rate (FR), transit time (TT), reliability (R) and service availability (SA). As discussed earlier in Section 2, in this paper the competitiveness of freight service is determined from these factors.

The survey was first pretested with the participation of professionals from both academic and industry sectors to ensure relevance and appropriate terminology for the sample. A stratified sampling strategy was adopted to frame the population under investigation. Stratified sampling is more accurate than simple random sampling, and generates a more representative sample with respect to each stratum (Onwuegbuzie et al., 2010). In addition, by using online survey tools, researchers can observe the response rate in each stratum and reach a greater sample (Gosling et al., 2004, Fricker, 2008). The organizations' contact information was mainly collected from the Australian Rail Directory and their websites. Accordingly, the invitation to participate in the online survey was sent to operations and senior managers using email and LinkedIn. LinkedIn was used as a powerful tool to identify, contact and direct the participants to the online survey as personal contact information of participants was not publicly available. Once the participants were identified, data collection was anonymously commenced from 17 August to 17 September 2014. Of the 200 survey questionnaires distributed, 66 completed responses were received, resulting in a response rate of 33.1 percent.

After the data were collected, exploratory factor analysis (EFA) was conducted for the four FSAs to identify the underlying factors against the quality of individual FSAs. EFA is a powerful statistical tool that explores a factor's structure for a set of observed variables without imposing a predetermined structure on the outcome (Suhr, 2006). In the next stage, mutual factors among all FSAs were identified. This provided the opportunity to identify and priorities the impediments that are most influential on all the FSAs.

5. Analysis of Results

To evaluate the influence of impediments on the FSAs, the factors derived from the systematic literature review were scaled from 1 being "not at all influential" to 5 being "very influential". All the mean values of the responses are significantly higher than the midpoint of the Likert scale (2.5), revealing that respondents are generally aware of the impeding factors and their impact on different service attributes. Table 1 presents the mean values of respondents' answers with regard to the influence of impediments to different FSAs. Different mean values for each FSA shows that impeding factors have diverse influences on different aspects of service quality.

Table 1. Influentially degree of impediments to FSA

Code	*Impediment*	*FR*	*TT*	*R*	*SA*
I.1	Inadequate below rail infrastructure	3.1	4.0	4.1	3.9
I.2	Inadequate intermodal terminal infrastructure	3.0	3.5	3.7	3.8
I.3	Shortage of above rail infrastructure	2.8	3.5	3.7	3.8
I.4	Rail's inability to provide door-to-door service	3.1	3.2	3.1	3.2
I.5	Poor interoperability between player	3.0	3.2	3.2	3.2
I.6	Lack of national rail operations standards	2.5	2.7	2.9	2.7
I.7	Poor freight distribution systems	2.9	3.2	3.2	3.2
I.8	Different types of pallets and containers	2.5	2.1	2.2	2.4
I.9	High terminal charges	3.5	2.2	2.3	2.4
I.10	Inefficient terminal operations	3.3	3.6	3.6	3.1
I.11	Diverse management of infrastructure	2.6	3.0	2.9	3.0
I.12	Inconsistent access charging regimes	3.8	2.5	2.7	2.8
I.13	Lack of common vision in government	3.2	3.0	3.0	3.1
I.14	Lack of support from government	3.5	3.1	3.2	3.3
I.15	Inconsistent public-private partnership policies	2.8	2.5	2.5	2.7
I.16	Uncertainty about capacity for growth	3.3	2.8	3.0	3.6
I.17	Diverse demand and growth patterns	3.2	2.9	3.0	3.3
I.18	Shortage of reliable data on rail freight	2.6	2.8	3.2	2.9
I.19	Poor information sharing and access	2.8	3.0	3.1	3.3
I.20	Shortage of skilled human resource	3.0	3.2	3.4	3.1
I.21	Over-regulation in the rail sector	3.2	3.1	3.0	3.0
I.22	Slow adaption of technology in the rail sector	3.3	3.3	3.3	3.2
I.23	Lack of integrated supply chain thinking	3.5	3.4	3.5	3.3
I.24	Poor performance history of the rail sector	2.9	2.6	2.9	3.1
I.25	Poor customer relationship management	3.1	2.8	3.0	3.0
I.26	Trade unions influence on productivity	3.1	3.2	3.3	3.1
I.27	Adversarial relationship between players	3.2	3.2	3.2	3.2
	Loadings	***84.1***	***82.6***	***85.3***	***85.7***
	Average	***3.1***	***3.0***	***3.2***	***3.1***
	FR: Freight rate TR: Transit time, R: Reliability, SA: Service availability				

Source: Authors

The descriptive statistics provided in Table shows the impacts of each impediment on different FSAs. This analysis however, presents a general overview and further analysis is required to reduce data to a smaller set of summary variables and to explore the theoretical structure on how FSA are affected. Accordingly, EFA with principal component analysis (PCA) was conducted to bring inter-correlated variables together under general underlying variables. Moreover, as some factors do not have strong applicability to a particular FSA, conducting EFA was important to remove them for the subsequent analysis.

Johnson and Wichern (2014, pp. 519-520) explained that the choice of the number of common factors is based on a combination of (i) the proportion of the sample variance explained; (ii) subject-matter knowledge; and (iii) the reasonableness of the results. The reduction of a large number of factors into an adequate number with a clear factor structure is the ultimate aim of factor extraction (Pallant, 2013). Therefore, the Kaiser Criterion is used to determine the number of the principal components. Table 2 details the rescaled rotated component matrix for the four FSAs.

Table 2. Rescaled rotated component matrix for four FSAs

	Components								
	1	*2*	*3*	*4*		*1*	*2*	*3*	*4*
	FR					***TT***			
I.7	***0.862***	0.068	0.097	0.273	***I.27***	***0.819***	-0.037	0.031	0.033
I.5	***0.79***	-0.087	0.179	0.294	***I.5***	***0.790***	0.026	0.165	0.094
I.8	***0.777***	0.221	0.037	-0.159	***I.7***	***0.761***	0.235	0.145	0.203
I.10	***0.646***	0.512	0.219	0.035	***I.26***	***0.693***	-0.052	0.273	0.175
I.12	0.043	***0.766***	0.213	0.299	***I.10***	***0.559***	0.383	0.321	-0.43
I.21	0.050	***0.760***	0.168	-0.045	***I.9***	0.114	***0.895***	0	0.246
I.9	0.215	***0.688***	0.246	0.144	***I.15***	0.098	***0.796***	0.088	-0.002
I.20	0.110	0.171	***0.805***	0.233	***I.12***	-0.113	***0.728***	0.095	0.289
I.26	-0.004	0.263	***0.805***	-0.118	***I.1***	-0.002	0.001	***0.87***	0.009
I.27	0.277	0.204	***0.742***	-0.016	***I.2***	0.278	0.126	***0.784***	0.042
I.1	-0.007	0.100	0.062	***0.926***	***I.3***	0.395	0.117	***0.703***	0.178
I.2	0.302	0.161	-0.021	***0.786***	***I.6***	0.161	0.276	0.103	***0.809***
					I.8	0.389	0.377	0.135	***0.665***
	R					***SA***			
I.18	***0.848***	0.165	0.198	0.235	***I.12***	***0.902***	-0.034	0.091	0.114
I.19	***0.829***	0.213	-0.006	0.157	***I.9***	***0.783***	-0.205	0.294	-0.096
I.23	***0.789***	0.298	0.014	0.138	***I.13***	***0.775***	0.341	-0.162	0.056
I.5	0.276	***0.852***	-0.034	0.103	***I.14***	***0.741***	0.327	0.135	0.119
I.10	0.096	***0.711***	0.055	0.354	***I.18***	0.172	***0.861***	0.176	0.256
I.11	0.095	***0.703***	0.267	-0.044	***I.19***	-0.024	***0.804***	0.223	0.194
I.27	0.547	***0.633***	0.159	0.057	***I.5***	0.003	0.259	***0.834***	0.089
I.26	0.373	***0.548***	0.201	0.043	***I.10***	0.108	0.011	***0.776***	0.319
I.12	-0.055	0.143	***0.893***	0.115	***I.27***	0.169	0.575	***0.642***	0.031
I.13	0.331	-0.091	***0.793***	0.010	***I.26***	0.199	0.474	***0.557***	-0.023
I.9	-0.223	0.280	***0.755***	-0.041	***I.1***	-0.019	0.146	0.053	***0.878***
I.14	0.304	0.163	***0.744***	0.116	***I.2***	0.163	0.191	0.236	***0.773***
I.1	0.180	0.029	-0.016	***0.861***					
I.2	0.185	0.200	0.163	***0.795***					

Extraction method: principal component analysis
Rotation method: Varimax with Kaiser normalization
Rotation converged in seven iterations
Source: Authors' estimation, SPSS 21 output

16

PCA identified four underlying components for each FSA and reduced the number of factors from 27 to 12 for freight rate, 13 for transit time, 14 for reliability and 12 for service availability. EFA offered not only the opportunity to gain a clear understanding of the data, but also the possibility to explore the underlying factors for subsequent analysis. In addition, EFA was crucial to identify the factors common among all FSAs.

For each FSA the impeding factors are categorized under their relevant theme. These themes represent the rail industry challenges for improving the freight service quality. The underlying factors related to freight rate are labelled as (i) interoperability, (ii) poor policy and infrastructure charging, (iii) human resource and organizational relationship and (iv) inadequacy of rail infrastructure. The main factors linked to transit time are labelled as (i) interoperability and organizational relationship, (ii) poor transport policy and access charging, (iii) inadequacy of rail infrastructure and (iv) poor operational standards. For reliability the main factors are (i) poor communication and supply chain integration, (ii) interoperability and organizational relationship (iii) poor transport policy and (iv) inadequacy of rail infrastructure. Finally, the main factors associated with service availability are (i) poor policy, (ii) lack of robust communication and integration, (iii) interoperability and organizational relationship, (iv) inadequacy of rail infrastructure. A detailed logistical analysis of themes in relation to service competitiveness is discussed in the following section.

6. Discussion of results

This paper investigates the influence of impeding factors faced by the Australian rail industry on various quality aspects of rail freight service. The findings provide important implications for both industry and government in terms of making transport planning and policy decisions. These are discussed in the following sub-sections for each FSA.

6.1 Freight rate

Although over the last two decades the demand for a more reliable and flexible freight service has been increasing, the freight rate is still a key determinant of modal shift in freight markets (Wijeweera et al., 2014). Thus, this FSA is discussed in more depth than those in other sections. According to Australasian Railway Association (ARA), efficient rail should provide a significantly lower cost freight transport system than road on all corridors; for example a 30 percent lower cost on the North-South corridor, and 50 percent on the East-West corridor (Port Jackson Partners, 2005). However, this has not been achieved to date. It is important to know that these estimates are based on the line-haul component of the freight trip, and not the overall door-to-door intermodal service. Therefore, the pick-up/delivery legs and the terminal handling charges offset the cost advantage of rail in the line-haul component Godwin et al., 2013). This problem is also demonstrated by the result of the survey where a key impeding area in relation to cost effectiveness of the rail sector is interoperability. The first component of the EFA includes items *I.5*, *I.7*, *I.8* and *I.10* which are all linked to the issue of interoperability. Interoperability refers to the point where freight and information are exchanged between different operators and modes. This component is not linked to the line-haul operations of freight trains, but to the efficiency of interaction between rail and road in the intermodal terminals and a lack of control over the distribution system when the pick-up/delivery tasks are undertaken. In addition to the terminal operation, participants demonstrated that different sizes of pallets and containers potentially add extra cost to the freight rate. This is particularly true as different sizes of handling units require additional equipment, excessive handling operations and results in poor utilization of space.

The second component in the EFA is directly linked with the cost-related impediments, including high terminal charges (*I.9*), inconsistent infrastructure access charging between road and rail (*I.12*) and over-regulation in the rail sector (*I.21*). Terminal handling charges are one of the highest cost components of an overall intermodal journey (Shipping Australia, 2011). The Australian Competition and Consumer Commission (ACCC) has expressed important concerns about terminal handling charges and competition structure which can significantly impact the overall efficiency of the intermodal chains. ACCC has an explicit focus on the charging strategies across the seaports in which there may be conditions where an operator is able to use its position to unfairly hold back a new entrant from establishing itself at that port and/or at other ports (ACCC, 2013). This will consequently abolish productivity in the markets where competition is limited. Inconsistent access charging is also a key concern for the rail sector. Due to long distances between the main population centers, freight trains operate within a very limited passenger market to share the fixed infrastructure cost, whereas nearly 90 percent of traffic on interstate road corridors (where rail and road compete for freight volumes) is comprised of light vehicles (ARTC, 2006, Ghaderi et al., 2015a). Another key issue for the rail sector which was identified in the survey was over-regulation, mainly due to the excessive cost that it imposes to operations. The adverse impact of multiple regulatory systems (safety and access) has an adverse impact by increasing the bureaucratic and administrative costs as the objectives set by one regulator may not be in alignment with objectives set by another (BTRE, 2006a).

The shortage of skilled human resources *(I.20)*, influence of trade unions on productivity *(I.26)* and adversarial relationship between freight players *(I.27)* also influence freight cost. The National Transport Commission (NTC) has raised two important concerns in relation to training and skills development which potentially determine the cost efficiency and subsequent freight rates offered by the rail sector. Firstly, it was emphasized that the current rail sector workforce has very little understanding of how intermodal chains operate (NTC, 2004). As a consequence, it is suggested that productivity improvement initiatives will not be effective until this understanding is achieved. Lastly, the shortage of below-rail (I.1) and

19

intermodal (I.2) infrastructure revealed the necessity for developing a nationally significant infrastructure for the rail freight sector that is cost effective. This issue is particularly essential in the metropolitan and port areas in which the freight trains share the infrastructure with the highly prioritized passenger trains.

6.2 Transit time and reliability

Long transit time and poor reliability levels offered by the rail sector are a key concern of freight customers in Australia, hindering their use of rail for many freight movements (Ernst & Young, 2006). The estimates from the Bureau of Infrastructure, Transport and Regional Economics (BITRE) suggest that the average door-to-door transit times offered by road are 20 percent less than those of line-haul rail. This means once the pick-up/delivery and terminal operations times are added, the differential door-to-door transit times between road and rail is much greater (BITRE, 2009). Additionally, reliability levels of rail have remained around 40 to 50 percent on the key interstate corridors, while road's reliability has been around 95 to 98 percent (BITRE, 2009). The focus of respondents' answers to this area is very similar to those of the freight rate, including factors linked with interoperability, terminal operations and shortage of infrastructure (*I.1, I.2, I.3, I.5, I.7, I.8, I.10, I.26 and I.27*). Respondents also indicated that poor information sharing (*I.18*) and shortage of reliable data on freight were of concern (*I.19*).

Rail operations have little control over the transit time of the overall freight journey. Therefore, efficient and effective integration between the different parties involved in undertaking the intermodal freight service determines the total time that freight requires reaching the customer's destination. Although enhancing track or terminal productivity or implementing new operational practices are essential to improve service quality, a higher level of collaboration and coordination is required across the entire intermodal chain (as demonstrated by *I.23*). Rail actors must understand how the timeliness and punctuality of their task influences the performance of up-stream tasks, and consequently the quality of time-based attributes of the freight service.

6.3 Service availability

Service availability for an intermodal rail service is defined as the number of weekly trains operating between two given points or the line segment of the network. Unlike road transport, the mobility of freight trains is naturally limited by the extent to which the below-rail infrastructure is developed. Therefore, decision making on service availability is a complex process and involves various factors, including locomotive availability, rolling stock availability, track usage and the accessibility of intermodal infrastructure to the freight markets. Reflecting the substantial gauge differences that exist across the Australian railway network, train operators face further challenges as different gauge sizes require distinct above-rail infrastructure (locomotive and rolling stock). This does not only impose excessive costs to the train operator, but also significantly restricts the mobility of the above-rail infrastructure across the network. The survey results indicate that inadequate below-rail (*I.1*) and intermodal infrastructure (*I.2*) are key impediments to service availability. This is particularly true in the case of Australia as the railways and intermodal system have not penetrated into regional areas. In contrast, the road network is soundly developed, meaning that road has a major advantage over rail in terms of service availability in regional areas. In addition to infrastructure shortage, the service availability of rail has a correlation with cost factors, including access charging prices (*I.12*), terminal charges (*I.9*) and lack of support and common vision to support rail from different levels of government (*I.13 and I.14*). Railway systems have strong economies of scale through density in above-rail and below-rail operations, meaning that incremental traffic volumes will have significant impact on reducing the carrying unit operational cost (BTRE, 2006b). Most of the Australian railway network is under-utilized and operated under low traffic volumes, implying low financial returns (BTRE, 2006a), and indicating that with the current state of infrastructure rail cannot be commercially viable in many areas of the market. However, this is not an issue in urban areas, especially those parts of the network linked to ports where rail corridors are too short to ensure economies of scale (Ghaderi et al, 2015c). Therefore, improving rail's service availability is a complex issue for both the government and the rail sector, requiring significant investment in infrastructure or heavy subsidization of freight rates.

To conclude this section, it was demonstrated in Table 2 that eight impediments are communal among the four FSAs, including *I.1*, *I.2*, *I.5*, *I.9*, *I.10*, *I.12*, *I.26* and *I.27*. These impediments are categorized as infrastructure management and operations (*I.1*, *I.2* and *I.10*), interoperability (*I.5*), infrastructure access charging (*I.5* and *I.1*) and organizational and commercial relationships (*I.26* and *I.27*). Conducting EFA for all FSAs was found to be useful to (i) reduce the number of factors to those that are most important from the rail sector perspective; (ii) identify the unique impediments associated with each FSA; and (iii) to understand what challenges are common among all FSAs. Figure 3 demonstrates the summary of data analysis and synthesis.

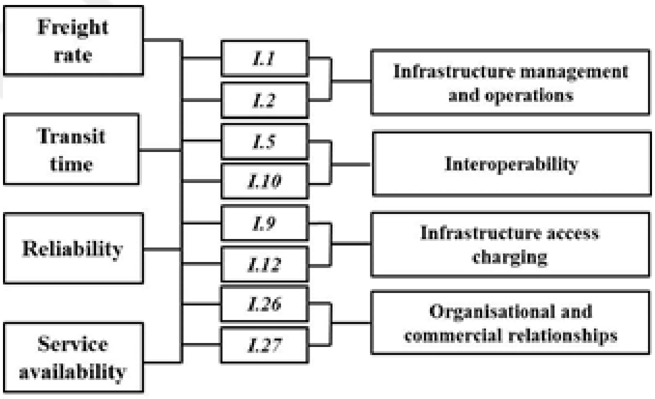

Figure 3. Summary of data analysis and synthesis
Source: Authors

7. Findings, recommendations and direction for future research

The previous sections provided important implications related to the factors affecting the competitiveness of the Australianrail sector. The main objective of this paper was to identify the key factors influencing the quality of different FSAs, and consequently the overall competitiveness of the rail sector. The result of EFA identified factors that are explicit to a particular FSA, but also those which are common. This is an important achievement as it assists the rail industry and government to target the poor FSAs and the associated impediments. The analysis shows that three key areas of challenge exist relating to (i) infrastructure management; (ii) interoperability; and (iii) organizational and commercial relationships. The findings of this paper have the following managerial implications and recommendations for improving the current rail service.

First, non-bulk freight is becoming an increasingly important part of the rail freight sector in Australia. This task is projected to grow much faster than the rate of population growth and the average national GDP growth. To cater for the projected demand, further development of rail infrastructure is required, including standardization of available gauges, opening of new freight corridors in the urban areas (especially ports) and establishment of new intermodal terminals. Particularly in the low-populated areas, small and medium-sized terminals are key facilitators for attracting cargo for rail.

Second, poor interoperability between different operators and modes is a key issue to the competitiveness of the rail sector in Australia. A lack of integration in terms of the physical movement of freight and information is where inefficiencies arise. For example, lack of integration may result in duplication of activities within the exchange points, excessive dwell times, congestion and additional equipment. The findings rising from this paper suggest greater standardization is required to enhance integration and interoperability.

Standardization is delineated in various ways, including harmonization in the transaction of information, standardization of unit loads and elimination of unnecessary inspections.

Third, an adversarial relationship and culture appears to exist across the non-bulk freight industry. In addition, the rail sector has failed to manage its organizational ties across the system. This failure is not only limited to the relationships between the rail sector and other key actors (including road, ports and terminal operators), but also it is a severe issue between the different parties involved in the operation of freight trains, especially between above-rail and below-rail operators. Reflecting the operational complexity of intermodal rail freight in size and interaction, greater collaboration is required to achieve productivity in the rail sector.

The implications derived from this study indicate that the freight rate is still a key area for rail to achieve competitive advantage. Taking into account the natural characteristics of rail transport, it is challenging for rail to easily provide better levels of transit time (especially on short corridors), reliability and service availability. Therefore, the recommendations provided in this section must take this key point into the decision making process.

This paper makes several contributions to the industry and academia. Firstly, it provides a more transparent image of the key challenges faced by the rail sector in Australia. These challenges were ambiguous previously, mainly due to lack of empirical research and absence of stakeholder involvement. This research therefore, provides a detailed understanding of these challenges in a national context. Secondly, this paper also contributes to the disciplines of competitiveness and systems management by developing a conceptual framework which integrates the systems approach into the competitiveness concept. This approach is beneficial to evaluate the competitiveness of an industrial sector by identifying its particular components (inputs, processes and outputs) and investigate how these components influence the competitiveness.

24

This research provides several directions for future research. Firstly, this paper investigated the view of rail freight sector on the key challenges on various service quality attributes. As a future research, the importance of different service attributes from the shippers and freight forwarders perspectives can be studied to be integrated with the outcomes of this thesis. This in consequence, will provide valuable information for the rail sector to target the poor attributes which demand higher service levels from the freight customers. Further investigation is required on understanding the poor FSAs in different sub-markets (including interstate, intrastate and port-based) and investigating the associated unique impediments. This would allow the freight operators and government to identify the poor FSAs in different sub-markets and make relevant infrastructure and planning decision making.

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APPENDIX A-6 – Paper VI

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Corresponding Author: Mr. Hadi Ghaderi,

Corresponding Author's Institution:

First Author: Hadi Ghaderi

Order of Authors: Hadi Ghaderi; Stephen Cahoon, PhD; Hong-Oanh Nguyen, PhD

Abstract: The Australian domestic freight activity has doubled in size over the past 20 years, averaging growth of 3.5 per cent per annum with the intermodal sector measuring the fastest growth rate. Thus, as the movement of freight by a variety of modes becomes a dominant model and pressure mounts to ensure that the integration of these modes is efficient and effective the role of intermodal terminals in sustaining the distribution systems becomes more prominent. Using both primary and secondary data, this paper provides an analysis of the trends in the Australian rail freight task and evaluates the current infrastructure in terms of capacity and efficiency to accommodate this trend, particularly in different sub-markets. This detailed understanding is a key facilitator for policy makers and freight operators to better utilise the available resources, as well as informed planning decisions for sustainable infrastructure developments.

*Title Page with Author Information

The role of intermodal terminals in the development of non-bulk rail freight market in Australia

Hadi Ghaderi[1], Stephen Cahoon[2] and Hong-Oanh Nguyen[3]

hghaderi@amc.edu.au

[1, 2 and 3]Department of Maritime and Logistics Management, National Centre for Ports and Shipping, Australian Maritime College, Launceston, Tasmania, Australia

The role of intermodal terminals in the development of non-bulk rail freight market in Australia

1. Introduction

Australia is a large nation far from its international markets. The ability to efficiently and effectively undertake the freight task substantially determines its international competitiveness and national sustainability. The Australian domestic freight activity has doubled in size over the past 20 years, averaging growth of 3.5 percent per annum with the non-bulk (intermodal) sector measuring the fastest growth rate (BITRE, 2014a). In this paper, the European Union's definition of intermodality is applied which is 'the movement of goods in one and the same loading unit (e.g. a container) or vehicle which uses successively several modes of transport without handling the goods while changing modes' (OECD, 2002, , p. 77).

Thus, as the movement of freight by a variety of modes becomes a dominant model, and pressure mounts to ensure that the integration of these modes is efficient and effective (Rodrigue and Notteboom, 2009; Regmi and Hanaoka, 2015), the role of intermodal terminals in the distribution systems becomes more prominent (Bontekoning and Priemus, 2004; Meyrick and Associates, 2006). Woodburn (2012) states that the development of intermodal freight is regarded as a key mechanism for rail achieving a greater share of the freight markets. Since the introduction of the AusLink Green Paper in November 2002, Australia has been recognising the importance of rail transport in terms of relieving capacity constraints on roads, whilst lowering freight transport costs and reducing the environmental impacts of freight sector as evidenced by recent government policy documents (NTC, 2009; BITRE, 2010; Infrastructure Australia, 2011). Despite the growing attention being given to

Therefore, this research aims to develop a more in-depth understanding of the role c intermodal terminals in the development of the non-bulk rail freight market in Australia b using various published and original data sources. To meet this objective, a review of th international literature on intermodal rail transport including rail is presented first. Then, th Australian rail freight activity and policy is discussed, focusing on the non-bulk task and th changes that occurred since the development of Australian Rail Track Corporation (ARTC) The next section discusses the system of intermodal terminals in Australia in relation to ra: activity and evaluates the current challenges faced by the rail sector. This is followed b detailed explanation of the role in the non-bulk freight market as a whole and thei contribution in generating freight volumes for rail in different subsystems and th methodology applied. Using both primary and secondary data, this paper provides an analysi of the trends in the Australian rail freight task and evaluates the current infrastructure i terms of capacity and efficiency to accommodate this trend, particularly in different sub markets. This detailed understanding is a key facilitator for policy makers and freigh operators to better utilise the available resources, as well as informed planning decisions fo future infrastructure developments. The key findings of this research and implications fc managerial practice are presented in Section 6.

2. Overview of intermodal freight transport research in relation to rail activity

In the last two decades, intermodal transport has become a substantial sector of the transpoı industry (Frémont and Franc, 2010). At the same time, academic literature on intermoda terminals has increased including the promotion of an active role for rail in the non-bul freight markets. This is mainly due to the increasing challenges created by road congestior environmental concerns and traffic safety (Caris, Macharis, and Janssens, 2008). Bontekoning et al. (2004) support that intermodal transport research is emerging and there is a need for further research into methods and techniques to address the challenges inherent in this field.

As earlier indicated by Woodburn (2008), two research streams can be observed from the available body of academic interest on intermodal terminals. First, there are studies with a theoretical basis that examine the physical development of terminals by applying modelling to optimize the number and location of facilities across the transport networks. This includes research dealing with simulating the terminal design for the efficient operation of freight trains. Secondly, there are studies that are associated with governance and planning frameworks that promote rail in the non-bulk freight markets. The emphasis of this paper is linked with the second research stream which principally focuses on the different policies on infrastructure planning and investment decisions, and competition policies. This area of research is particularly important as any decision on terminal development and location requires a higher level of policy approval (Bergqvist, 2008). However, there is limited and fragmented literature available in this area (Caris, Macharis, and Janssens, 2008). The following discussion briefly presents the relevant literature on intermodal transport in relation to rail activity.

By identifying recent trends in the British non-bulk rail freight market, Woodburn (2007) indicates that intermodal markets (especially to and from ports) are potentially better to capture the premium logistics traffic for rail in the less-than-trainload (LTL) markets. In the same year, Tsamboulas et al. (2007) developed a methodology to assess the potential of a specific policy measure to produce a modal shift in favour of intermodal transport. Their proposed methodology is a valuable tool for policy makers to assess whether a specific transport policy positively affects intermodal transport (Tsamboulas, Vrenken, and Lekka, 2007). This is achieved by increasing its mode share and assessing the competitiveness of intermodal transport to and from a specific region. This approach can also be potentially beneficial to assess suitability of a particular policy to promote rail in regions where different intermodal markets exist.

A key element for non-bulk rail freight transport to achieve a greater share is the extent to which intermodal terminals meet the requirements of the system. In Woodburn's (2008) investigation of the relationship between the development of intermodal terminals and service provision in Britain, he concludes that effective land-use planning for the development of rail terminals is essential to attract regional cargo and increase efficiency. Roso et al. (2009) took a different perspective by examining the concept of dry ports in relation to rail operations. Their contribution suggests that distant dry ports assist rail become more competitive, which results in a greater modal shift from road. This is potentially beneficial for rail operators as a distant terminal offers exponential economies of scale.

In Dablanc's (2009) investigation of the regional policies for intermodal rail freight services, he focuses on the reluctant role of the local governments to promote rail in France. The reluctance was explained due to the conditions of limited infrastructure capacity, low productivity levels, and a high cost of labour. The operation of intermodal terminals is a labour intensive task. This is especially true in the case of Australia where low regional volumes plus high labour costs are considered as key barriers to a commercially viable rail freight system. The intermodal sector has also gained significant attention in Europe over the last two decades. A recent study conducted by Woodburn (2012) examines the evolution of the intermodal sector in Britain by focusing on the contribution of different sub-markets to the overall growth trend. The findings of this study reveal that most of the recent intermodal rail growth in Britain has resulted from greater volumes carried between seaports and hinterland terminals.

The relationship between the provision of intermodal infrastructure and development of rail freight markets is complex. This means a clear understanding of this linkage is essential to justify infrastructure planning and investment decision making. Despite the increasing number of studies undertaken by academia and industry on intermodal terminals, a lack of quantitative and market-based analysis is apparent. A common theme in the body of literature is the lack of detailed analysis to identify the role of intermodal terminals in different sub-markets which contributes to a greater share for rail at a national level. In other words, intermodal terminals have been studied from an operational (internal) perspective, rather than as their role as key facilities for enhanced integration across the freight network. In addition, the focus of the extant literature is principally on large-scale road-rail terminals rather than on the role of intermodal terminals, in particular where gauge differences exist, as key facilitators that integrate rail networks and attract regional volumes. This is particularly important as the availability of a door-to-door freight service across different markets substantially determines the competitiveness of the rail transport and intermodal sector as a whole. Therefore, this research aims to fill the quantitative gap between the development of intermodal terminals and the resultant rail activity.

3. Australian rail freight activity and policy

The freight sector provides a substantial contribution to Australia via economic growth and employment and accounts for 14 percent of gross domestic product (GDP) (Infrastructure Australia, 2011). In the last decade, freight transport has gained further momentum in Australia, partly due to the significant demand growth at both domestic and international levels and partly as a result of the public's concern on Australia's future needs for infrastructure decision making (Ghaderi, Cahoon, and Nguyen, 2015). The major reasons contributing to this growth are increased trade between capital cities, growth in Australia's population, and increased mining activity.

The total value of this task in terms of non-bulk freight equated to approximately two percent of Australia's GDP in 2008[1], of which the interstate corridors comprised 61 percent, international chains (port-based) 34 percent, and the intrastate chains five percent of the total value (Booz & Co, 2008a).

With respect to the infrastructure, the railway network consists of approximately 33,000 route-kilometres of track (BITRE, 2012). In common with the experience in some other countries (such as the United States, Germany and Britain), Australia's railway network was constructed with different gauges. The network developed outwards from the State capitals, with cross-border links coming only after intrastate lines were well developed. While that legacy remains to this day, interstate trains operate uninterrupted across a common 1,435 mm 'standard' gauge which consists of 17,381 route-kilometres in 2014 (BITRE, 2014b). Figure 1 demonstrates the Australian railway network by track gauge.

[1] Transport economic-based data on the domestic freight task is not regularly generated; this is the most current data available.

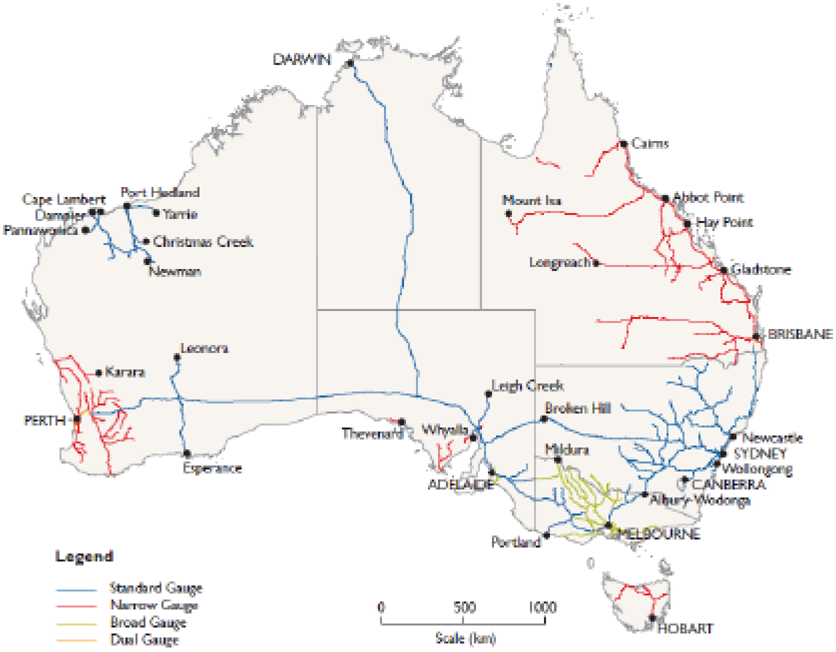

Fig 1. Rail network by track gauge (BITRE, 2012, , p. 7)

As a part of microeconomic reforms implemented by the Australian Government over the past two decades deregulation of rail started by vertically separating the management and operation of above and below rail infrastructure (Everett, 2008). However, deregulation of rail and the creation of the national interstate network have failed to bring integration and instead delivered a system consisting of discrete State Government entities. These systems have complex access regimes, pricing strategies and regulatory mechanisms which were established in isolation, and not necessarily based on national interests and enhanced integration, but instead for the benefits of the respective State Governments (Everett, 2006). Table 1 provides a summary of the principal intermodal track managers including both interstate and intrastate networks by their vertical integration.

Table 1
Principal infrastructure managers of lines used for intermodal movement

Infrastructure manager	*Vertical integration*	*Location*
Interstate		
ARTC	Separated	Brisbane–Kalgoorlie, via Melbourne and Broken Hill [excluding track around Sydney–Newcastle]
Brookfield Rail	Separated	Kalgoorlie–Perth
Genesee & Wyoming	Integrated	Tarcoola-Darwin
Intrastate		
Queensland Rail	Integrated (mostly)	Non-coal lines in Queensland (including West Moreton coal)
V/Line	Separated	Intrastate Victoria
TasRail	Integrated	Tasmania

Source: Data extracted from *Trainline1* (BITRE, 2012)

ARTC is the primary manager of interstate track, with Kalgoorlie-Perth managed by Brookfield Rail and Genesee and Wyoming for the Central corridor. ARTC has invested more than three billion Australian dollars into the interstate freight network over the last five years to improve service quality. Most of it has been allocated to the North-South corridor because of its importance to Australia's economy and supporting the businesses distributed along this strategic transport corridor (ARTC, 2012).

In recent years, rail infrastructure pricing and access charging systems have been debatable subjects between policy makers, infrastructure owners and users. The access of freight trains to below rail infrastructure in Australia is generally priced to recover at least the incremental cost of infrastructure use, which includes the marginal cost of track maintenance (BTRE, 2003; Productivity Commission, 2005). In many railway systems in Europe and North America, the cost recovery objective is based on full cost recovery rather than a margin of incremental costs. Most of Australia's rail infrastructure access is based on a negotiate-arbitrate model, where the access seeker and provider negotiate access but, if negotiation fails, the regulatory body sets an arbitrated charge that falls within the floor-ceiling price band (BTRE, 2003). The owners of the rail infrastructure are obliged, where requested, to provide access to the track to above-rail train operators with fair and reasonable conditions. The terms and conditions as well as the price of such access are regulated by Part IIIA of the *Trade Practices Act 1974* or by relevant State legislation (Wills-Johnson and Affleck, 2006). The access pricing has been held down by the ARTC to assist the rail industry in gaining market share (ARA, 2005). However, current charges may not sustain the infrastructure costs in the long-run, and hinder new investment from commercial operators in the rail sector.

When it comes to the trends in market share, long-distance non-bulk freight, which was predominately carried by rail for the first half of last century, has largely shifted to road transport (BITRE, 2013). The road freight share has been growing almost sixfold over the last four decades due to significant productivity and technology improvements in both the road network and vehicles (Kamakaté and Schipper, 2009). The introduction of larger capacity vehicles, such as B-doubles, B-triples and road-trains has created new opportunities for the road sector to compete with rail in the longer freight corridors such as Melbourne-Brisbane (Ghaderi et al., 2013).

Poor reliability and long transit times are regarded as the major reasons for the low use of rail in the non-bulk market by freight customers (Ghaderi et al., 2015). On the rail North–South rail corridor that transports freight along the Eastern States between Melbourne, Sydney, and Brisbane, on-time reliability until recently has been approximately 40 to 50 percent compared with road's 95 to 98 percent (Ernst & Young, 2006; ALC, 2008; Booz & Co, 2008b). Of interest however, is that transporting non-bulk freight by rail typically involves transhipment between road and rail, leading to less flexibility, increased freight cost, and negative impact on transit time and reliability. In this sense, intermodal terminals are the key facilities for rail to provide a door-to-door service in the non-bulk freight market, and the efficiency of the transfer between modes has a significant impact on the competitiveness of rail service (Kozan, 2006).

4. The system of intermodal terminals in relation to rail operations

The effectiveness of the entire intermodal chains can be substantially determined by the performance of the intermodal terminals. As stated in Booz and Co.'s (2008a, p. 41) report submitted to the National Transport Commission, 'the intermodal supply chains are complex in Australia, with participants ranging from multi-billion dollar companies, whose operations stretch across the globe and whose scope of services lead their presence in each part of intermodal industry, to sole traders who provide a single freight service to one geographic area'.

This section provides a background to the organization of intermodal terminals and summarizes the key trends arising from the published sources on this subject in relation to rail freight operation in Australia. Understanding the different intermodal terminals sub-systems and their particular contribution to the non-bulk rail freight market is import to assist the Government to make informed infrastructure and transport planning decisions.

In general, there are three distinctive sub-systems of intermodal terminals in Australia: (i) a port-based system that predominantly handles international import and export, (ii) a system that is concerned with the interstate movements of non-bulk freight and (iii) the intrastate system that operates between the capital cities and regional areas. Although there is no definitive rule to entirely differentiate these sub-systems, to a significant extent these sub-systems increasingly operate independently of each other (Meyrick and Associates, 2006). A number of terminals (Yennora in Sydney for example) play a critical role in more than one sub-system.

In the port-based sub-system, three major stevedores operate the Australian container terminals. Patrick Terminals operates container terminals in Melbourne, Sydney, Brisbane and Fremantle with capacity to handle 3.9 million TEU annually, DP World's terminals are in

Melbourne, Sydney, Adelaide, Brisbane and Fremantle, and Hutchinson Ports Holding have been operating terminals in Sydney and Brisbane since 2008. In 2008, Patrick Terminals held 53 percent, or approximately 2.8 million TEU, of Australia's international container handling market, with DP World handling 47 percent or 2.5 million TEU (Booz & Co, 2008a).

Among the Australian capital cities, Sydney has the most extensive intermodal terminal system in terms of rail connectivity to the port. However, pressure from highly prioritized passenger trains on freight trains that use the same infrastructure is extreme. At the same time, curfews in many parts of the network restrict freight trains, significantly affect terminal productivity levels.

The intermodal terminal system in Victoria is comparatively less developed than in New South Wales. A key issue for the Port of Melbourne, as the largest container port in Australasia, is the quality of rail access to the on-dock terminals (Meyrick and Associates, 2006). The Port of Melbourne has no direct standard rail access to the docks. This means containers must be transhipped onto trucks for a few hundred metres in the port terminal area (Roso, 2013). In other words, the freight trains travelling through the Port of Melbourne are loaded and unloaded outside the dock terminals because of the complexity of its rail gauge system, adding extra transhipment cost and time to the freight service. Figure 2 demonstrates an example of the road/rail differential freight rate for the containers moving between Port Botany and a metropolitan destination in Sydney. Three scenarios are provided: (i) direct road, (ii) road via transport depot, and (iii) rail via intermodal terminal. This example indicates that in 2011, direct road represents the most efficient and cost effective mode of moving containers from the port to the consignee via a direct truck movement to the customer, including unloading and returning the empty container within the same day (Shipping Australia, 2011). The direct road model was 28 percent cheaper than road via transport depot and only three percent cheaper than rail via intermodal terminal. However, if the cost of road and rail door-to-door services is assumed even, rail will have a lower market share due to its low service quality in terms of transit-time, reliability and service availability.

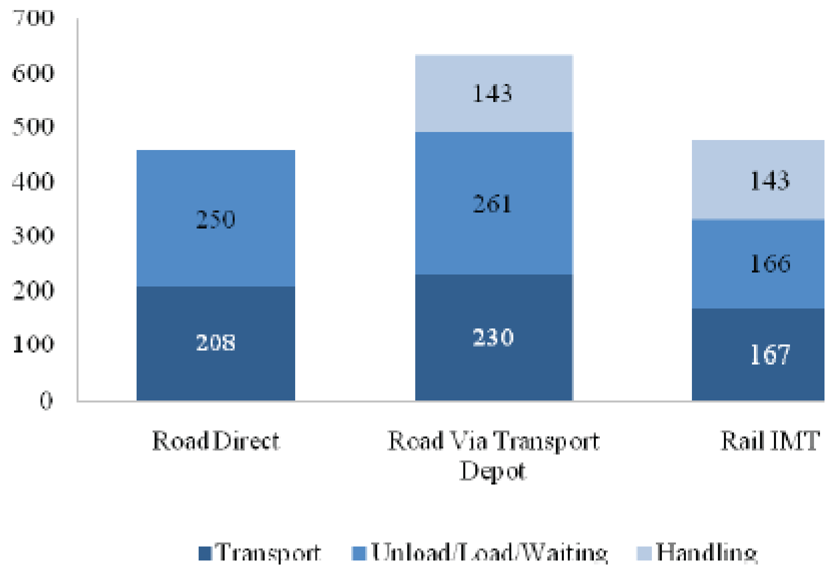

Fig 2. Estimated road and rail freight rates between Port Botany and consignee in the Sydney area (Australian dollars)
Source: Shipping Australia (2011, , p.12)

Distance is one of the major prerequisites determining the success of rail in the intermodal market, but also the volume of freight and the frequency of the service (Woxenius, 1998). In addition, the choice of location for an intermodal terminal is an essential component in a logistics system and is a paramount decision for the investors as well as the ports and customers (Bergqvist, 2008). In the cases of Sydney and Melbourne, the current volume and service frequency of port-based movements are sufficient, but the distances between port terminals serving the interstate terminals are noticeably short. Particularly in Melbourne, the average distance between urban intermodal terminals serving the near dock facility of the Port is approximately 20 km (Figure 3). This distance does not ensure the economic viability of operating port shuttles.

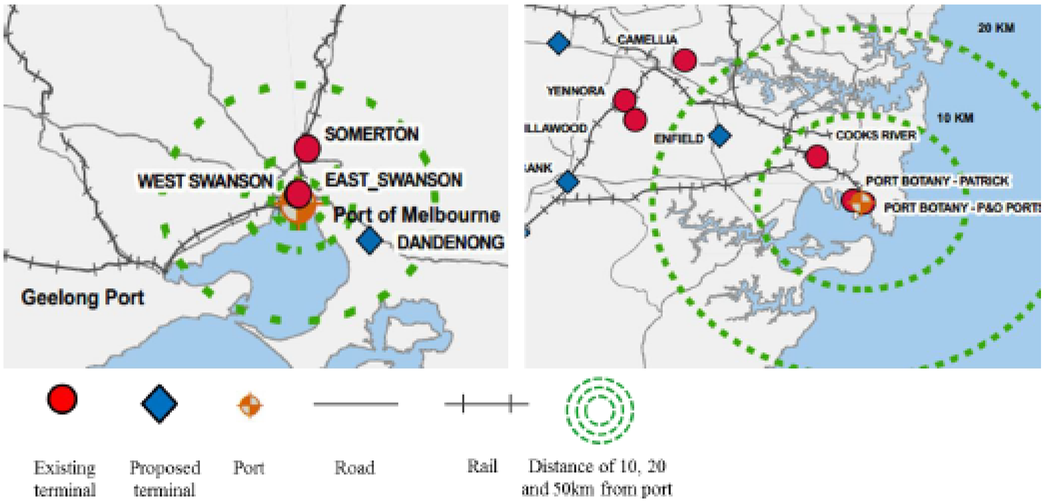

Fig 3. Spatial development of intermodal terminals in Melbourne and Sydney
Source: Adapted from Booz & Co (2009, Appendix 2)

The intermodal terminals in the hinterland of Port of Melbourne were developed in competition with the port itself, as the port did not have any interest to invest in them. This can be contrasted with the inland facility for Port Botany in Sydney which was designed to perform a complementary task for the port, leading to a higher level of integration (Roso, 2013).

The Port of Brisbane is of the fastest growing container ports in Australia, and Queensland's largest multi-cargo port. A near-dock intermodal facility is provided by the Brisbane Multimodal Terminal (BMT) which accommodates freight trains up to 850 metres with no scheduled standard-gauge container trains to the terminals (BITRE, 2014c). Containers are shifted by road from the terminal to the intermodal facility for the next leg of journey by rail.

Fremantle Port is the largest general cargo port in Western Australia and Australia's fourth largest container port. Container stevedoring is undertaken at North Quay in the Inner Harbour by Patrick Terminals (having four berths) and DP World (with three berths). Currently the rail sidings at North Quay terminal accommodates relatively short intermodal trains up to 450 metres in length (BITRE, 2014c). Port Adelaide is located 14 km north west of the city of Adelaide with two inner and outer harbours. The container terminal is operated by Flinders Adelaide Container Terminal and located in the outer harbour with dual standard and broad gauges with connectivity to the national network. Although the rail connectivity is satisfactory (1280 m length) in the container terminal, train operations are mainly short-haul.

Shifting the focus now to the interstate sub-system, intermodal terminals consist of facilities located mainly in the capital cities for the transfer of goods primarily between rail and road on the two major corridors of North-South and East-West. These facilities are generally connected to the interstate and regional rail networks with high productivity handling equipment, providing other functions such as warehousing, quarantine, and customs. Figure 4 demonstrates the interstate intermodal terminals by their location in each State.

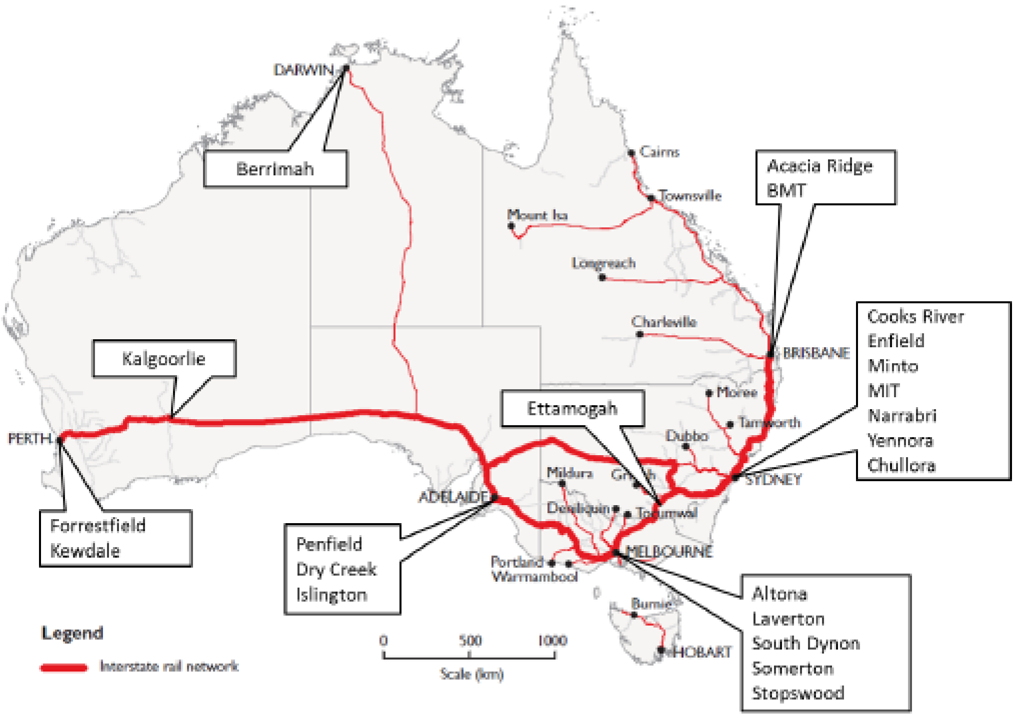

Fig 4. Australian interstate intermodal terminals on the interstate network
Source: Adapted from BITRE (2012)

14

The interstate terminals were primarily established for alleviating port congestion and the carriage of freight on the interstate network. As stated by Roso (2011), for short-haul rail a close dry port (intermodal terminal with direct rail connection to the seaport) is a potential solution for seaport terminal congestion as well as for better seaport inland access.

Although the major terminals are located in the capital cities, terminals (Ettamogah in Albury for example) are also strategically located in the junctions of transport networks to attract and consolidate smaller volumes. Interstate terminals are mainly owned and managed by subsidiary companies of above rail operators and below rail managers such as Pacific National, Toll Holdings, Queensland Rail, and Aurizon.

The intrastate sub-system of intermodal terminals was constructed to integrate the regional gauge passing the inner hinterland with the interstate network or ports. The most apparent example can be seen in Queensland where a distinctive system of terminals were mainly developed to move goods between Brisbane and both regional and coastal markets (Figure 5).

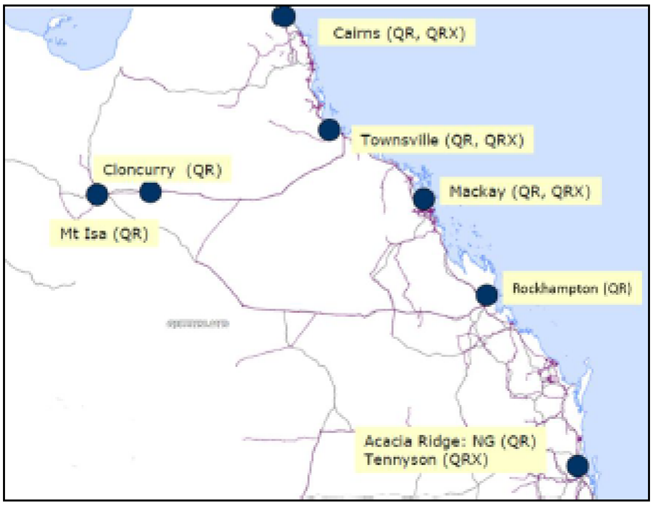

Fig 5. The Queensland intrastate intermodal terminal system
Source: Meyrick and Associates (2006, , p.26)

The unique feature of the intrastate sub-system is that the terminals are linked to a gauge other than the standard interstate gauge. Within this sub-system, terminal capacity varies between 10,000 to 100,000 TEU. These facilities act as distribution centres, providing warehousing and value-added logistics services (Meyrick and Associates, 2006; Shipping Australia, 2011). The management of terminals in the intrastate sub-system is diverse, ranging from heavily integrated corporations such as Pacific National to small companies whose business is limited to terminal operations.

The situation is comparatively different in Australia's State of Tasmania. The lack of physical land connection to the mainland offers no scope for rail in the interstate market. The Northern Tasmanian ports in particular, are well integrated with the State's rail network. In Tasmania, the complex trading relationships, demand constraint and scattered population has led to an oversupply of intermodal infrastructure in both port-based (such as Burnie, Bell Bay and Devonport) and intrastate sub-systems (Brighton Hub for example). With an outdated rail infrastructure (both above and below rail) and short-haul journey, rail is not as competitive due to the trucks traveling roads that are often congestion-free.

5. The role of intermodal terminals in the non-bulk rail freight market

This section explains how each intermodal sub-system contributes to the development of the non-bulk rail freight market in Australia using a range of published works and data sources. To meet this objective, the port-based sub-system is explained in relation to the trends and shares of road and rail in each capital city. The roles of the interstate and intrastate sub-systems are also explained in terms of providing a playing field for rail.

As stated before, the port-based sub-system provides an opportunity to shuttle trains from the port to the inner hinterland and vice versa. The number of containers carried by rail in or out of container terminals over a period of time is an indicator of these movements. The outbound movements of containers by rail in ports are through an on-dock rail siding in the container terminal, or a rail siding in the proximity of deep-sea terminal. Figure 6 demonstrates the total number of containers (including TEU and FEU) carried by rail in/out of terminals. No data regarding rail's share is currently available for the Port of Adelaide.

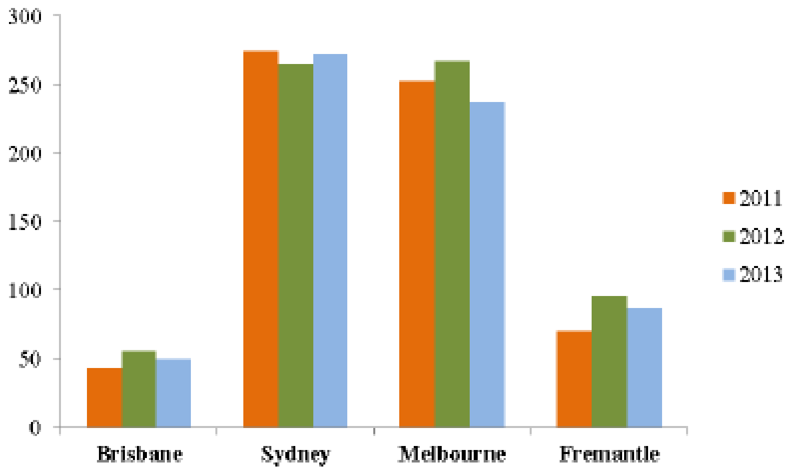

Fig 6. Total number of containers carried by rail in/out of deep-sea terminals excluding Adelaide (000 containers)
Source: calculated from BITRE (2014c, 2014d)

Further analysis and calculation of data from BITRE (2014c, 2014d) indicates that the share of rail from the deep-sea terminals market is significantly lower than those by road. Between 2011 and 2013, rail's share has been approximately eleven percent. Table 2 demonstrates the modal share between road and rail for the key Australian ports, excluding Adelaide.

Table 2
The total road-rail modal share of container traffic to/from key Australian ports excluding Adelaide (percentage)

	2011		2012		2013	
Port	*Rail*	*Road*	*Rail*	*Road*	*Rail*	*Road*
Brisbane	4.6	95.4	5.5	94.5	5.1	94.9
Sydney	14	86	14	86	11	89
Melbourne	11	89	12.6	87.4	11.5	88.5
Fremantle	11	89	14	86	15	85
Total	*11*	*89*	*12*	*88*	*11*	*89*

Source: Calculated from BITRE (2014c, 2014d)

DP World Melbourne has recently opened its 49 hectare West Swanson intermodal terminal to handle interstate trains. With the opening of this facility, it is expected that rail's share in Melbourne will increase due to enhanced connectivity and improvements in terminal infrastructure and operations.

According to the Metropolitan Intermodal Terminal Study (Shipping Australia, 2011) two major factors affect the performance of the train operation in ports. Firstly, there is a misalignment between the rail paths and the stevedores' time windows that create difficulties for rail operators to schedule service via the port. Secondly, insufficient rail capacity at the port terminals exists, including limited sidings and insufficient lifting productivity.

Shifting the focus to the interstate sub-system, two major corridors exist in which the intermodal terminals play a critical role in generating cargo for rail; the East-West and North-South corridors. The interstate corridors, which comprise 61 percent of the total non-bulk market value (as the largest component of the domestic container traffic), pass through the interstate sub-system (Booz & Co, 2008a).

In this analysis, it is assumed that all the interstate rail movements pass through interstate intermodal sub-system for two reasons. First, in all States (except some parts of NSW) the intrastate track is not as same as the interstate standard track, which makes it necessary to use interstate terminals to access the interstate standard gauge. Second, the port-based sub-system only provides short-distance rail shuttles from deep-sea terminals to road transport depots. Interstate or intrastate terminals and most of the ports do not use standard gauge. Figure 7 presents the tonnage-distance intermodal freight flows between Australian States.

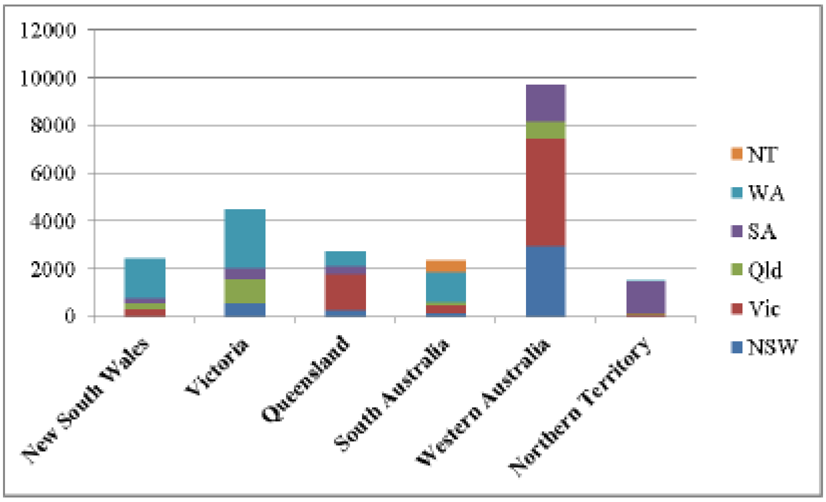

Fig 7. Interstate intermodal rail freight flows in 2009-10 (million net tonne-kilometres)
Source: data calculated from BITRE (2012, 2014d)

The non-bulk rail activity is most significant on the longer East-West routes (Perth origin and destination). In addition, the Melbourne-Brisbane corridor has approximately 30 percent share of the inter-capital non-bulk freight market (BITRE, 2014a) making it a potential market for rail to demonstrate its economies of scale over long distances. The third market field for rail is the intrastate non-bulk freight market. In terms of tonnage only 18 percent of the non-bulk traffic is intrastate and tends to be dominated by movements within Queensland (BITRE, 2012). In Queensland, the intrastate movements of non-bulk rail freight demonstrate very similar features in common with the interstate task.

The largest intrastate intermodal rail operators are QRX (now part of the Toll Group), Queensland Rail and Aurizon (Former QR National). These three operators own twelve major intermodal terminals handling intrastate freight mainly along the coast of Queensland.

Competition between operators plus the geographical proximity of intermodal markets in Queensland appear to have been facilitators of increased intrastate rail freight activity.

Although a less fully articulated system can be seen in Victoria, South Australia and NSW, the volumes are not significant. The intrastate intermodal sub-system provides a playing field for rail over shorter distances compared to long interstate origin-destination journeys, but longer than port shuttles. Figure 8 demonstrates the intrastate intermodal rail freight during 2009-10. Since the movement of intermodal freight by rail requires a terminal to shift the container on dedicated State's railway systems, the data is an indication of movements by intermodal terminals in each State.

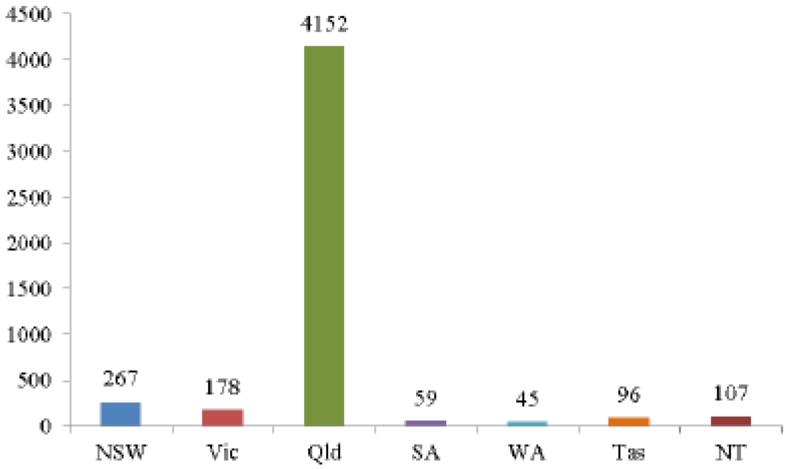

Fig 8. Intrastate intermodal rail freight flows during 2009-10 (million net tonne-kilometres)
Source: data calculated from BITRE (2012)

Roso (2013) states that besides the price-quality ratio of competing traffic modes, the competitiveness of intermodal road-rail transport depends on geographical and demographical conditions. (such as most of the Queensland's population being located along the coast line). The significant intrastate rail activity in Queensland for example, may be as a result of the existence of a well-defined system of intermodal terminals in the State and long distances between Brisbane and other major population centres in Queensland. Additionally, as explained in Section 2 the operation of intrastate intermodal freight trains is vertically integrated between the track manager and the above rail operator as a single entity in Queensland. This can be considered a critical success factor for the efficiency of rail operations and the subsequent market share.

To translate the tonnage estimates into container measures, the World Shipping Council (2010) states that in the Trans-Pacific trade in the US, export TEU weighed on average 12 tons and import TEU weighted on average 9 tons. Giving this assumption and using the data from BITRE (2012), Table 3 represents the estimated number of containers handled by interstate terminals for each pair-States and intrastate container moves in each State. The Tasmanian intrastate container flows equates to 31.1 and 25.6 for import and export calculations respectively.

Table 3
Estimated container flows moved by rail using interstate and intrastate intermodal terminals rail in 2009-10 (,000 containers)

State	*NSW*		*Vic*		*Qld*		*SA*		*WA*		*NT*	
	Import - Export											
NSW	112.7	92.2	134.2	109.8	26.7	21.8	9.9	8.1	84.1	68.8	1.3	1.1
Vic	32.7	26.7	72.2	59.1	82.9	67.8	42.2	34.5	146.2	119.6	6.2	5.1
Qld	22.6	18.5	56.7	46.4	478	391.1	6	4.1	15.7	12.8	0.7	0.5
SA	10.9	8.9	54.3	44.4	14.9	12.2	38.3	31.4	64.8	53	57.7	47.2
WA	47.4	38.8	78.7	64.4	12.9	10.5	52.1	42.6	7.8	6.4	1	0.8
NT	0	0	0	0	0	0	22.8	18.6	0	0	9.7	7.9

Note: Highlighted figures demonstrate the intrastate movements.

Source: Calculated from BITRE (2012)

In conclusion, each intermodal terminal sub-system provides a different scope for rail transport in the Australian non-bulk freight task. The trains departing from port-based terminals carry a relatively high number of containers over very short distances, involving port shuttles from the rail sidings in the port to the next destination in the inner hinterland which can be an interstate or intrastate terminal. The interstate intermodal terminals handle the trains carrying a large number of containers, travelling over long distances. This is the primary field in which rail demonstrates competitive advantage over road transport. The intrastate terminals present a middle ground role for rail. Trains travelling to/from the intrastate terminals carry a low number of containers compared to the interstate sub-system over comparatively longer distances than the port-based terminals. Reflecting the door-to-door nature of intermodal freight service, intermodal terminals not only provide an opportunity for rail in the abovementioned sub-markets, but also boost freight mobility and network integration.

6. Findings and recommendations

The former sections explained how intermodal terminals can promote an active role for rail in the non-bulk freight market in Australia, both from published statistics and original analysis conducted by the authors. The findings arising from this paper and detailed in below, suggest the need for improved planning decisions and development policies for intermodal terminals in Australia. These implications are:

- The share of rail in port-based container flows remains steady at about ten times lower than those for road. This is due to two main reasons, firstly, poor rail connectivity to ports which must pass through the congested parts of the rail network; and secondly, the high costs of stevedoring, siding, shunting and administration associated with the operations of rail in ports.
- For the intrastate movements, intermodal terminals are key facilities for rail to achieve a greater share. This was evidenced in Queensland's significantly higher share than other states as a result of its distinctive system.
- The fragmented and disjointed nature of rail infrastructure in Australia such as track incompatibility being a key impediment for the rail industry to be a competitive mode

of transport. This again highlights the critical role of intermodal terminals to improve this by efficiently and effectively facilitating the interactions across the network.

The findings arising from this paper and those above suggest the need for improved planning decisions and development policies for intermodal terminals in Australia.

To cater for the expected growth in Australia's seaborne and domestic trade, a combination of establishing new terminals (especially in the regional markets) and the expansion of certain existing terminals are required. In relation to capacity, sufficient terminal facilities are available in terms of handling and storage yards in all sub-systems. However, this capacity is not efficiently employed as the result of numerous infrastructural and regulatory constraints.

In the port-based sub-system, three elements are essential for a disruption-free movement of freight trains across Australian deep-sea terminals. First, the rail connectivity to the ports is a critical factor. In Sydney and Melbourne, dedicated rail corridors are needed to lessen the interfaces between the freight trains and highly prioritized passenger trains in the shared network. It is expected that rail may become more competitive in the future when increased urban trade and traffic make road transport less flexible and more costly in metropolitan Sydney and Melbourne.

Second, design and space-utilization are the physical determinants of operational efficiency for intermodal terminals. Poor design (lack of direct access to docks for example) in Australian ports has resulted in unavoidable and unnecessary inspection, transhipment and train shunting, thus diminishing rail's natural economies of scale. Therefore, greater rail infrastructure is required in port areas, especially rail sidings in container terminals to ease seamless transhipment.

The third element which does not appear to have been discussed in the literature (Ghaderi, Fei, and Cahoon, 2015) is allied with the internal planning and human resource management. As a result of poor and adversarial relationships between different players in the ports, rail productivity levels tend to be low. Many container terminals in Australia are unionised, and often there is one union covering a range of employees. The key stevedores in Australia are members of the Maritime Union of Australia (MUA), meaning that non-MUA members (who earn lesser wages) are not permitted to enter the terminal to work. This multifarious working environment has led to several strikes and stoppage of terminals operations in the last two decades such as 1998 Australian Waterfront Dispute. Therefore, a systematic approach needs to be in place to maintain the relationships within terminals, but also between terminal operators and other parties (transport operators for example). Better management of the human factors will not only enhance terminal productivity, but will also assist the terminal operators to deal with unexpected interruptions in the freight network.

Although there are similar circumstances faced by the interstate and intrastate sub-systems, the primary challenges are different. In other studies the views of key stakeholders such as Pacific National and Shipping Australia suggest that intermodal terminal capacity is not an issue in Australia (Meyrick and Associates, 2006; Shipping Australia, 2011). They believe that existing facilities are able to cope with the increased volumes and the future plans for the opening of new terminals (such as new Hutchinson port facilities in Sydney and Brisbane or Moorebank in Sydney or the Moorebank interstate hub in Sydney) and are sufficient to deal with the growing Australian freight task in the medium to long-term. However, the key concerns are about the management of terminals. In Australia, the management of intermodal terminals is diverse in operations and ownership. This has resulted to a number of access undertaking disputes over the past. Although many terminals must operate as common users, or open access facilities, there are examples where the terminal operator has particular interest in the above rail business.

As described in the earlier sections, the complexities arising from both the physical infrastructure and regulatory mechanisms involved in undertaking the non-bulk freight task in Australia have made it one of the most challenging logistics environment in the world for the operation of freight trains. Optimal physical, operational, and regulatory harmonisation is required to ensure efficient interoperability within the rail industry, but also between rail and other transport modes across the nation. To ensure an efficient and integrated non-bulk freight task, improved management of intermodal infrastructure is required to create seamless interaction between the different modes and coordination between different actors.

Another important issue as explained in Section 4 is that terminal handling rates are one of the largest cost components of an intermodal rail service. According to Australian Competition & Consumer Commission (ACCC), the real unit revenue earned by port stevedores was $154.69 on a 20-foot container in 2012-2013 (ACCC, 2013). Of interest is that Patrick Terminals, as the largest container terminal operator in Australia is vertically integrated with its rail operator subsidiary Pacific National as the largest national rail freight operator in Australia, providing different ranges of logistics services in other markets. From a rail-only operator's perspective, the question then arises if the superior profits gained from the stevedoring business have any impact on the market competition neutrality.

In order to have a competitive market, the intervention of government as the regulatory body is necessary to avoid individuals abusing their market power and pursuit of their pure self-interests. Poor control and intervention over the intermodal supply chains from the government and its different levels in the last three decades has resulted in a very fragmented development of intermodal network in Australia, in fact a set of competing intermodal chains developed by different operators. This approach is essentially against the co-modalism conception and utilization of available infrastructure by different users.

Effective implementation of a national land freight transport systems such as AusLink requires an active role of government to ensure interoperability. Although the role of government as an operator is fading, it may continue as the owner of below rail infrastructure and terminals in the future. To date, the government as a regulator, planner and policy maker has failed to develop a realistic and clear policy scheme to encourage efficiency and better allocation of assets across the intermodal chains. Furthermore, if container volumes are projected to double and the competition for land is becoming intense over the next 20 years, it remains a matter of serious concern as to how government will deal with the further complexities arising from these issues.

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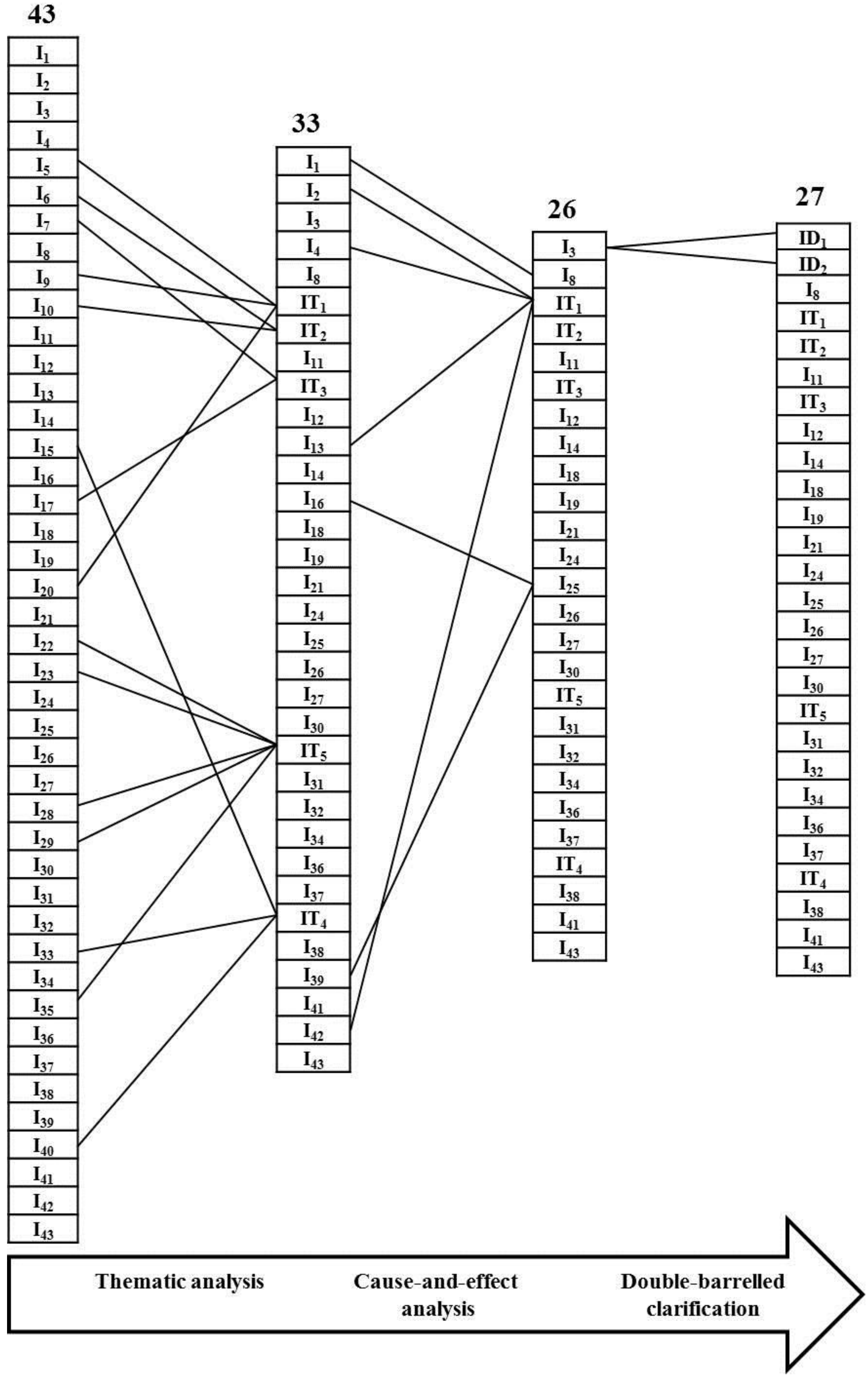
APPENDIX B – Refinement Process



APPENDIX C – Questionnaire

Evaluation of Impediments to the Competitiveness of the Australian Non-bulk Rail Freight Industry

(A National Study)

August 2014

Participant Information Sheet

Dear Stakeholder of the Rail Freight Industry,

Thank you for your interest in participating in this national study conducted by the Department of Maritime and Logistics Management at the Australian Maritime College (University of Tasmania). This information should be read in conjunction with the email inviting you to participate.

As explained in the email invitation, this study aims to identify and evaluate the impediments to the competitiveness of the rail industry in the Australian non-bulk freight market. Information collected from the survey will be analysed in order to gain a better understanding of the current impediments from different stakeholders' perspectives and provide solutions for the enhanced competitiveness of rail service.

You have been selected to participate in this study as an expert member of an organisation involved in the rail freight industry. Your participation involves completion of an online survey questionnaire that will take approximately 25 minutes.

Please note there is no foreseeable risk associated with participation in this study and you can withdraw at any time you wish. All information will be treated in a confidential manner and your anonymity and privacy will be ensured. All data will be kept in a password-protected computer file and will be destroyed five years after the data has been first published. If you have any further question, please contact Mr. Hadi Ghaderi by email (hghaderi@amc.edu.au) or phone (03 6324 9648).

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study you can contact the Executive Officer of the HREC (Tasmania) Network with the ethics reference number H0014314 on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote the ethics reference number.

Thank you for taking the time to participate in this study.

Hadi Ghaderi, PhD Candidate
Dr Stephen Cahoon, Chief Investigator
Dr Hong-Oanh Nguyen, Co-Investigator

To begin this survey it is first important that you provide your consent as a result of reading the Participant Information Sheet. Please click on one of the below boxes to indicate your consent and continue with the survey, or alternatively, exit the survey.

- ☐ I understand the implications of participating in this survey as a volunteer as explained on the previous page and I agree to continue the survey (Please continue to the survey).
- ☐ I do not wish to continue with the survey (You may exit the survey).

A. Information about your organisation

This section seeks information about the ownership and operations of your organisation.

A1. Please select the type of your organisation in relation to rail.

☐ Government regulatory body and policy maker
☐ Above rail operator/manager/owner
☐ Below rail operator/manager/owner
☐ Consultation/engineering/maintenance firm
☐ Terminal operator
☐ Freight forwarder/stevedoring /chartering
☐ Warehousing and distribution
☐ Coastal shipping
☐ Road haulage
☐ Port authority
☐ Representative
☐ Other:

B. Decision making and freight service attributes

This section includes information on factors influencing the shipper's decision when choosing a transport mode in the non-bulk market.

Please rate how influential the following factors are on your organisation's decision making.

B1. Freight rate

	1	2	3	4	5	6	7	
Not influential	☐	☐	☐	☐	☐	☐	☐	Very influential

B2. Transit time

	1	2	3	4	5	6	7	
Not influential	☐	☐	☐	☐	☐	☐	☐	Very influential

B3. Punctuality

	1	2	3	4	5	6	7	
Not influential	☐	☐	☐	☐	☐	☐	☐	Very influential

B4. Service availability

	1	2	3	4	5	6	7	
Not influential	☐	☐	☐	☐	☐	☐	☐	Very influential

C. Importance of impediments within Australian context

This section requests information on the significance of the impediments on your organisation's performance in the Australian non-bulk rail industry.

How important are the following possible impediments on the performance of the Australian non-bulk rail freight industry. Please rate each individually from 1 to 7 where 1 indicates not important at all and 7 indicates the impediment is very important.

No.	Impediment	Importance level
C.1	Inadequate below rail infrastructure base (such as tracks and signalling)	
C.2	Inadequate intermodal terminal infrastructure	
C.3	Shortage of above rail infrastructure such as rolling stocks and locomotives	
C.4	Inability of rail to provide a single-mode door-to-door service	
C.5	Poor inter-operability between different players in the non-bulk freight market	
C.6	Lack of national rail operations standards	
C.7	Poor freight distribution systems	
C.8	Different types of pallets and containers	
C.9	High terminal charges	
C.10	Inefficient terminal operations	
C.11	Diverse management of infrastructure	
C.12	Inconsistent charging policies between road and rail for accessing their infrastructure	
C.13	Lack of a common vision for the non-bulk rail freight sector between different levels of government	
C.14	Lack of support from different levels of government for the non-bulk rail freight sector	
C.15	Inconsistent public-private partnership policies	
C.16	Uncertainty about capacity for growth	
C.17	Diverse demand and growth patterns	
C.18	Shortage of reliable data on rail freight	
C.19	Poor information sharing and access in the non-bulk rail industry	
C.20	Shortage of skilled human resources	
C.21	Over-regulation of the rail sector	
C.22	Slow adoption of technology in the rail industry	
C.23	Lack of integrated supply chain thinking in the rail industry	
C.24	Poor performance history of the rail industry	
C.25	Poor customer relationship management in the rail industry	
C.26	Trade union influence on productivity	
C.27	Adversarial relationships between players in the non-bulk freight sector	
C.28	Please indicate any other impediment and its rating here	

D. Assessing the influence of impediments on the freight service attributes

The following sections involve considering the influence of the 27 impediments on each of the freight service attributes listed in Section B.

D (a) Infrastructure and integration

This section includes information on impediments relating to infrastructure inefficiencies and lack of integration. Please rate how influential the following impediments are on each of the rail freight service attributes from 1 to 5 where 1 indicates not influential at all and 5 indicates the impediment is very influential.

No.	Impediments	Freight rate	Transit time	Punctuality	Service availability
D.1	Inadequate below rail infrastructure base (such as tracks and signalling)				
D.2	Inadequate intermodal terminal infrastructure				
D.3	Shortage of above rail infrastructure such as rolling stocks and locomotives				
D.4	Inability of rail to provide a single-mode door-to-door service				
D.5	Poor inter-operability between different players in the non-bulk freight market				
D.6	Lack of national rail operations standards				
D.7	Poor freight distribution systems				
D.8	Different types of pallets and containers				
D.9	High terminal charges				
D.10	Inefficient terminal operations				
D.11	Diverse management of infrastructure				
D.12	Please indicate any other impediment and its rating here				

D (b) Governance and transport policy

This section includes information on impediments relating to government and transport policy on the non-bulk rail freight industry. Please rate how influential the following impediments are on each of the rail freight service attributes from 1 to 5 where 1 indicates not influential at all and 5 indicates the impediment is very influential.

No.	Impediments	Freight rate	Transit time	Punctuality	Service availability
D.13	Inconsistent charging policies between road and rail for accessing their infrastructure				
D.14	Lack of a common vision for the non-bulk rail freight sector between different levels of government				
D.15	Lack of support from different levels of government for the non-bulk rail freight sector				
D.16	Inconsistent public-private partnership policies				
D.17	Please indicate any other impediment and its ratings here				

D (c) Growth

This section provides information on impediments relating to the future growth of the non-bulk freight market. Please rate how influential the following impediments are on each of the rail freight service attributes from 1 to 5 where 1 indicates not influential at all and 5 indicates the impediment is very influential.

No.	Impediments	Freight rate	Transit time	Punctuality	Service availability
D.18	Uncertainty about capacity for growth				
D.19	Diverse demand and growth patterns				
D.20	Please indicate any other impediment and its ratings here				

D (d) Managerial, organisational and leadership factors

This section includes information on impediments relating to managerial, organisational and leadership factors. Please rate how influential the following impediments are on each of the rail freight service attributes from 1 to 5 where 1 indicates not influential at all and 5 indicates the impediment is very influential.

No.	Impediments	Freight rate	Transit time	Punctuality	Service availability
D.21	Shortage of reliable data on rail freight				
D.22	Poor information sharing and access in the non-bulk rail industry				
D.23	Shortage of skilled human resources				
D.24	Over-regulation of the rail sector				
D.25	Slow adoption of technology in the rail industry				
D.26	Lack of integrated supply chain thinking in the rail industry				
D.27	Poor performance history of the rail industry				
D.28	Poor customer relationship management in the rail industry				
D.29	Trade union influence on productivity				
D.30	Adversarial relationships between players in the non-bulk freight sector				
D.31	Please indicate any other impediment and its ratings here				

E. Please provide your opinion on the following questions

As we are approaching the end of the survey, this section provides a space for you to express your opinions freely on the non-bulk rail freight transport. We also encourage you to provide any other views or concerns you have in the space provided at the end of this section.

E1. How effective are the current transport policies for promoting the use of rail in the non-bulk freight market?

E2. What changes are required to improve the quality of rail freight services in the Australian non-bulk freight market?

E3. If you are a port operator/manager, over the next five to ten years how do you see the role of rail changing in relation to the movement of containers to and from your port? (Only for port authorities)

E4. If you are a port operator/manager, what are the factors that will determine whether your port will invest in rail infrastructure in your port over the next five to ten years? (Only for port authorities)

E5. If you are a port operator/manager, does your port have a preference for the use of either road, rail or short sea shipping for the movement of your port's container-based movements? Please explain what is your preference and why. (Only for port authorities)

E6. Finally are there any other views on how the rail industry can be more competitive over the next five to ten years?

F. Some information about you

This section includes information about your position, affiliated department and work experience in the freight industry as this will assist the study identify differing views of participants in the survey.

F1. Please indicate your current position in your organisation:

☐ Chief executive officer
☐ Managing director
☐ Department head
☐ Senior manager
☐ Other, please specify:_______________

F2. In which division/department do you currently work?

☐ General administration
☐ Commercial
☐ Marketing
☐ Operational and technical
☐ Human resource management
☐ Finance
☐ Policy and advisory
☐ Other, please specify:_______________

F3. How many years have you been associated with the freight industry?

☐ No direct experience
☐ Less than one year
☐ 1-5 years
☐ 6-10 years
☐ 11-15 years
☐ 16 years and above

F4. How many years have you been associated with the rail industry?

☐ No direct experience
☐ Less than one year
☐ 1-5 years
☐ 6-10 years
☐ 11-15 years
☐ 16 years and above

Thank you for your participation in this survey. We highly value your contribution and time spent on this research, if you have any question please contact Mr. Hadi Ghaderi by email at hghaderi@amc.edu.au.

A summary of the results of this study is available by requesting a copy by email to the above address.

APPENDIX D – Ethics Approval

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
Fax: (03) 6226 7148
Katherine.Shaw@utas.edu.au

UTAS

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

15 August 2014

Dr Stephen Cahoon
Maritime and Logistics Management
Private Bag 1397

Dear Dr Cahoon

Re: MINIMAL RISK ETHICS APPLICATION APPROVAL
Ethics Ref: H0014314 - Evaluation of Impediments to the Competitiveness of the Australian Non-bulk Rail Freight Industry

We are pleased to advise that acting on a mandate from the Tasmania Social Sciences HREC, the Chair of the committee considered and approved the above project on 15 August 2014.

This approval constitutes ethical clearance by the Tasmania Social Sciences Human Research Ethics Committee. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approval of other bodies or authorities is required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

Please note that this approval is for four years and is conditional upon receipt of an annual Progress Report. Ethics approval for this project will lapse if a Progress Report is not submitted.

The following conditions apply to this approval. Failure to abide by these conditions may result in suspension or discontinuation of approval.

1. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval, to ensure the project is conducted as approved by the Ethics Committee, and to notify the Committee if any investigators are added to, or cease involvement with, the project.

A PARTNERSHIP PROGRAM IN CONJUNCTION WITH THE DEPARTMENT OF HEALTH AND HUMAN SERVICES

2. Complaints: If any complaints are received or ethical issues arise during the course of the project, investigators should advise the Executive Officer of the Ethics Committee on 03 6226 7479 or human.ethics@utas.edu.au.

3. Incidents or adverse effects: Investigators should notify the Ethics Committee immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Amendments to Project: Modifications to the project must not proceed until approval is obtained from the Ethics Committee. Please submit an Amendment Form (available on our website) to notify the Ethics Committee of the proposed modifications.

5. Annual Report: Continued approval for this project is dependent on the submission of a Progress Report by the anniversary date of your approval. You will be sent a courtesy reminder closer to this date. **Failure to submit a Progress Report will mean that ethics approval for this project will lapse.**

6. Final Report: A Final Report and a copy of any published material arising from the project, either in full or abstract, must be provided at the end of the project.

Yours sincerely

Ethics Officer
Tasmania Social Sciences HREC

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APPENDIX E – Paper II Statistical Details

Exploratory Factor Analysis – The SPSS output

Table E2 – Communalities (Principal Component Analysis extraction)

	Initial	Extraction
C.2	1.000	.621
C.4	1.000	.561
C.7	1.000	.727
C.9	1.000	.837
C.10	1.000	.699
C.16	1.000	.706
C.18	1.000	.848
C.19	1.000	.779
C.24	1.000	.776
.C.25	1.000	.802
C.26	1.000	.722
C.27	1.000	.835
C.11	1.000	.726
C.20	1.000	.477

Table E3 –Four-factor (final) unrotated component matrix

	Component			
	1	2	3	4
C.11	.789	.012	-.058	-.316
C.7	.780	-.225	.180	-.191
C.2	.770	.055	-.010	-.160
C.18	.741	-.246	-.485	.056
C.10	.721	.303	-.121	-.271
C.19	.676	-.193	-.420	.329
C.4	.647	-.227	.290	-.087
C.25	.641	-.206	.495	.322
C.16	.634	-.399	-.373	.079
C.27	.630	.543	.177	.332
C.9	.628	.377	.069	-.544
C.24	.550	-.476	.486	.102
C.20	.529	.254	-.157	.329
C.26	.486	.616	.074	.318

Confirmatory Factor Analysis – The AMOS output

Tables E4 – Original model findings

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	34	133.153	71	.000	1.875
Saturated model	105	.000	.000		
Independence model	14	677.614	91	.000	7.446

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	0.184	0.83	0.749	0.561
Saturated model	.000	1		
Independence model	0.886	0.308	0.201	0.267

Baseline Comparisons

Model	NFI	RFI	IFI	TLI	CFI
	Delta1	rho1	Delta2	rho2	
Default model	0.803	0.748	0.898	0.864	0.894
Saturated model	1		1		1
Independence model	.000	.000	.000	.000	.000

Parsimony – Adjusted Measure

Model	PRATIO	PNFI	PCFI
Default model	0.78	0.627	0.698
Saturated model	0	0	0
Independence model	1	0	0

NCP

Model	NCP	LO 90	HI 90
Default model	62.153	33.486	98.636
Saturated model	.000	.000	.000
Independence model	586.614	507.604	673.099

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	1.604	0.749	0.403	1.188
Saturated model	.000	.000	.000	.000
Independence model	8.164	7.068	6.116	8.11

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	0.103	0.075	0.129	0.002
Independence model	0.279	0.259	0.299	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	201.153	216.153	283.801	317.801
Saturated model	210	256.324	465.236	570.236
Independence model	705.614	711.79	739.645	753.645

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	2.424	2.078	2.863	2.604
Saturated model	2.53	2.53	2.53	3.088
Independence model	8.501	7.549	9.543	8.576

Hoelter

Model	HOELTER	HOELTER
	0.05	0.01
Default model	58	64
Independence model	14	16

Assessment of Normality

Variable	Min	Max	Skew	C.R.	Kurtosis	C.R.
I25	1	7	-0.614	-2.299	0.068	0.128
I24	1	7	-0.537	-2.008	-0.338	-0.632
I16	1	7	-0.772	-2.889	0.108	0.201
I9	1	7	-0.596	-2.229	-0.305	-0.571
I20	1	7	-0.653	-2.442	0.352	0.659
I27	1	7	-0.599	-2.24	0.105	0.197
I26	1	7	-0.418	-1.564	-0.642	-1.2
I4	1	7	-0.652	-2.441	-0.493	-0.922
I7	1	7	-1.048	-3.922	0.605	1.131
I19	1	7	-0.52	-1.947	0.486	0.91
I18	1	7	-0.616	-2.304	0.064	0.12
I2	1	7	-1.198	-4.481	1.664	3.114
I11	1	7	-0.632	-2.365	0.001	0.002
I10	1	7	-1.159	-4.337	0.944	1.766
Multivariate					51.677	11.188

Tables E5 – Final model findings

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	25	19.715	20	0.476	0.986
Saturated model	45	.000	.000		
Independence model	9	386.038	36	.000	10.723

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	0.098	0.951	0.891	0.423
Saturated model	.000	1		
Independence model	0.914	0.375	0.218	0.3

Baseline Comparisons

Model	NFI	RFI	IFI	TLI	CFI
	Delta1	rho1	Delta2	rho2	
Default model	0.949	0.908	1.001	1.001	1
Saturated model	1		1		1
Independence model	.000	.000	.000	.000	.000

Parsimony – Adjusted Measure

Model	PRATIO	PNFI	PCFI
Default model	0.556	0.527	0.556
Saturated model	.000	.000	.000
Independence model	1	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	.000	.000	14.34
Saturated model	.000	.000	.000
Independence model	350.038	290.61	416.923

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	0.238	.000	.000	0.173
Saturated model	.000	.000	.000	.000
Independence model	4.651	4.217	3.501	5.023

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	0.093	0.7
Independence model	0.342	0.312	0.374	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	69.715	76.564	130.485	155.485
Saturated model	90	102.329	199.387	244.387
Independence model	404.038	406.504	425.916	434.916

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	0.84	0.843	1.016	0.922
Saturated model	1.084	1.084	1.084	1.233
Independence model	4.868	4.152	5.674	4.898

Hoelter

Model	HOELTER	HOELTER
	0.05	0.01
Default model	133	159
Independence model	11	13

Assessment of Normality

Variable	Min	Max	Skew	C.R.	Kurtosis	C.R.
I27	1	7	-0.599	-2.24	0.105	0.197
I26	1	7	-0.418	-1.564	-0.642	-1.2
I4	1	7	-0.652	-2.441	-0.493	-0.922
I7	1	7	-1.048	-3.922	0.605	1.131
I19	1	7	-0.52	-1.947	0.486	0.91
I18	1	7	-0.616	-2.304	0.064	0.12
I2	1	7	-1.198	-4.481	1.664	3.114
I11	1	7	-0.632	-2.365	0.001	0.002
I10	1	7	-1.159	-4.337	0.944	1.766
Multivariate					25.238	8.219

Table E1 – Descriptive statistics of the item

Item number	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
C.1	84	1.00	7.00	5.4286	1.48312	-1.163	.949
C.2	84	1.00	7.00	5.3452	1.37529	-1.220	1.843
C.3	84	1.00	7.00	5.0714	1.51129	-.875	.409
C.4	84	1.00	7.00	4.3810	1.74179	-.664	-.449
C.5	84	1.00	7.00	4.8571	1.62171	-.996	.275
C.6	84	1.00	7.00	4.6310	1.55059	-.569	-.323
C.7	84	1.00	7.00	4.7024	1.49521	-1.067	.717
C.8	84	1.00	7.00	3.8214	1.62926	-.184	-.614
C.9	84	1.00	7.00	4.7262	1.66720	-.607	-.249
C.10	84	1.00	7.00	5.3690	1.50325	-1.180	1.078
C.11	84	1.00	7.00	4.7381	1.47362	-.644	.076
C.12	84	1.00	7.00	4.8333	1.72042	-.695	-.037
C.13	84	1.00	7.00	5.3571	1.32304	-1.330	2.434
C.14	84	1.00	7.00	5.1905	1.49276	-.936	.686
C.15	84	1.00	7.00	4.6786	1.49828	-.663	.380
C.16	84	1.00	7.00	4.8690	1.60406	-.786	.189
C.17	84	1.00	7.00	4.9643	1.52447	-.754	.353
C.18	84	1.00	7.00	4.7381	1.48177	-.627	.143
C.19	84	1.00	7.00	4.6190	1.28855	-.530	.592
C.20	84	1.00	7.00	4.9167	1.45791	-.665	.449
C.21	84	1.00	7.00	4.8810	1.35686	-.431	.295
C.22	84	1.00	7.00	5.0238	1.41401	-.803	.475
C.23	84	1.00	7.00	5.0238	1.52865	-1.181	.982
C.24	84	1.00	7.00	4.6429	1.57268	-.546	-.284
C.25	84	1.00	7.00	4.8690	1.48713	-.626	.148
C.26	84	1.00	7.00	4.8333	1.72741	-.426	-.607
C.27	84	1.00	7.00	4.7619	1.58014	-.610	.187

APPENDIX F – Paper III Statistical Details

Tables F1 – Communalities of four EFA tests with Principal Component Analysis

Freight rate

	Initial	Extraction
C.5	1.000	.751
C.7	1.000	.832
C.8	1.000	.679
C.10	1.000	.728
C.9	1.000	.601
C.12	1.000	.722
C.21	1.000	.611
C.26	1.000	.731
C.27	1.000	.670
C.1	1.000	.872
C.2	1.000	.736
C.20	1.000	.744

Transit time

	Initial	Extraction
C.5	1.000	.661
C.7	1.000	.696
C.26	1.000	.588
C.27	1.000	.674
C.10	1.000	.746
C.9	1.000	.875
C.12	1.000	.636
C.15	1.000	.651
C.1	1.000	.758
C.2	1.000	.710
C.3	1.000	.695
C.6	1.000	.768
C.8	1.000	.754

Reliability

	Initial	Extraction
C.9	1.000	.700
C.12	1.000	.835
C.13	1.000	.746
C.14	1.000	.686
C.18	1.000	.841
C.19	1.000	.757
C.5	1.000	.814
C.23	1.000	.731
C.27	1.000	.728
C.1	1.000	.775
C.2	1.000	.733
C.10	1.000	.643
C.26	1.000	.481
C.11	1.000	.577

Service availability

	Initial	Extraction
C.1	1.000	.795
C.2	1.000	.716
C.5	1.000	.771
C.9	1.000	.750
C.10	1.000	.716
C.12	1.000	.837
C.13	1.000	.746
C.14	1.000	.688
C.18	1.000	.868
C.19	1.000	.734
C.26	1.000	.575
C.27	1.000	.772

Tables F2 - The SPSS output of unrotated component matrices

Freight rate

	Component			
	1	2	3	4
C.10	.783	.046	-.247	-.229
C.7	.690	.527	-.277	.045
C.9	.669	-.223	.126	-.298
C.12	.641	-.255	.365	-.337
C.27	.639	-.342	-.162	.345
C.20	.632	-.332	.121	.468
C.5	.611	.515	-.255	.216
C.8	.552	.240	-.530	-.190
C.2	.512	.497	.476	.024
C.21	.508	-.393	.093	-.435
C.26	.500	-.604	-.068	.334
C.1	.380	.375	.749	.162

Transit time

	Component			
	1	2	3	4
C.7	.765	-.135	-.298	.059
C.3	.712	-.226	.336	-.155
C.8	.705	.318	-.210	-.334
C.5	.669	-.352	-.294	.056
C.26	.641	-.368	-.186	-.089
C.2	.632	-.240	.497	-.075
C.27	.579	-.398	-.411	.109
C.9	.556	.716	-.014	.230
C.12	.380	.683	.150	.053
C.15	.467	.530	.114	.373
C.1	.411	-.244	.706	-.177
C.10	.583	-.219	.121	.587
C.6	.529	.409	-.164	-.542

Reliability

	Component			
	1	2	3	4
C.27	.797	-.161	-.218	-.143
C.18	.772	-.224	.349	-.270
C.23	.709	-.362	.146	-.277
C.5	.696	-.261	-.501	.103
C.19	.679	-.390	.231	-.300
C.26	.653	-.042	-.220	-.074
C.14	.629	.500	.178	-.087
C.10	.616	-.141	-.325	.371
C.11	.577	.125	-.476	.042
C.12	.461	.778	.081	.103
C.9	.334	.735	-.189	.111
C.13	.482	.583	.340	-.242
C.1	.386	-.252	.463	.590
C.2	.546	-.103	.333	.560

Service availability

	Component			
	1	2	3	4
C.27	.783	-.231	-.294	-.138
C.18	.766	-.239	.230	-.413
C.26	.674	-.135	-.293	-.128
C.14	.669	.472	.089	-.104
C.5	.646	-.344	-.443	.199
C.19	.642	-.390	.134	-.391
C.10	.600	-.213	-.277	.485
C.2	.583	-.174	.446	.384
C.12	.514	.741	.058	.142
C.9	.399	.683	-.266	.232
C.13	.507	.598	.243	-.269
C.1	.401	-.291	.626	.397

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